MUSCLE ACTIVITY AND GAIT ANALYSIS OF ASSISTIVE DEVICE FOR GAIT ABNORMALITIES PATIENT

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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MUSCLE ACTIVITY AND GAIT ANALYSIS OF ASSISTIVE DEVICE FOR GAIT ABNORMALITIES PATIENT

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons)

by

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2021

DECLARATION

I hereby, declared this report entitled "Muscle Activity and Gait Analysis of the Assistive Device for Gait Abnormalities Patient" is the results of my own research except as cited in reference.

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Date : 21 January 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 the degree of Bachelor of Manufacturing Engineering with Honours. The members of the supervisory committee are as follow

……………………………………

(RUZY HARYATI BINTI HAMBALI)

ABSTRAK

Gait abnormalities merupakan satu penyakit yang mengakibatkan pesakitnya tidak boleh berjalan dengan lancar. Penyakit ini berpunca daripada beberapa faktor antaranya, genetik, kemalangan, masalah kesihatan, dan beberapa faktor lain lagi. Sesetengah penyakit ini boleh dirawat namun terdapat juga sesetengah kes yang tidak dapat dipulihkan dan hanya boleh dibantu dengan cara pemulihan atau fisioterapi. Penyakit ini boleh mengganggu aktiviti seharian pesakit kerana ketidakselesaan pada bahagian kaki pesakit untuk berjalan secara normal. Satu alat untuk menyokong meringankan beban pesakit telah dihasilkan, namun kajian keatas keberkesanan dan sejauh mana alat tersebut dapat membantu meringankan masalah ini belum dikenal pasti. Oleh itu, satu alat yang dikenali sebagai Electromyography (EMG) digunapakai dalam mendapatkan maklumat tersebut. Selain itu, kajian ini adalah untuk melihat perbezaan antara keadaan saraf manusia normal dan saraf pesakit. Di samping itu, kajian ini bertujuan untuk melihat keberkesanan alat sokongan ini dalam mengurangkan regangan saraf yang dihadapi pesakit dalam pada masa yang sama mampu maningkatkan masa untuk saraf menjadi letih, (time-to-fatigue). Akhir sekali, kajian ini bertujuan untuk menganalisa perbezaan keadaan saraf pesakit tersebut dengan memakai dan tanpa memakai alat bantuan. Berdasarkan kepada kajian ini, keputusan dan analisa yang Berjaya diperolehi ialah berlakunya kadar pengurangan dalam peratusan nila purata RMS (%) terhadap regangan saraf pesakit dalam masa yang sama mampu meningkatkan masa yang diambil untuk saraf pesakit menjadi lemah. Kajian ini telah berhasil mengurangkan keletihan pada saraf seterusnya membantu para pesakit dalam melakukan kehidupan seharian dengan lebih mudah.

ABSTRACT

Gait abnormality (GA) is a muscle disorder that disabling the patient to walk properly. This is caused by several factors including genetic influence, accident history, health issue, and others. Some who suffered from this illness can be cured but there are some other cases which the patients are not be able to be fully cured and only can be helped by physiotherapy. The disability to walk properly caused by this muscle disorder can affect the patient's daily activities as they feel the difficulty to walk properly as a normal person could. An assistive device to help the patient to walk has been developed however the effectiveness on the device's performance to serve its purpose has not yet been confirmed. Therefore, an electrical tool known as the Electromyography (EMG) is being used to obtain the information required. Besides, this research is to analyse the comparison of the patient's nervous system with the assistant device and without the device. In addition, the main purposes of this research is to study the effectiveness of the assistive device in reducing the muscle contraction faced by the patients at the same time to increase the time-to-fatigue of the muscle. Thus, the findings of this research show that the reduction in percent of average RMS (root mean square) value to the patient's contraction muscle when using the device which in return has increase the time-to-fatigue of the muscle. Last but not least, this research has achieved the objective which is to minimize the muscle fatigues in order to ease the patient in their daily chores.

DEDICATION

Only

My beloved father, Komaruddin bin Hussain

My appreciated mother, Maznah binti Mohammad

My adored siblings, Liana, Marzuki, Aisyah, Rahmah, Amirah, Ilham

My supportive supervisor, Mdm Ruzy Haryati, my friends, UTeMs' staff and everyone who directly or indirectly involved in this research for giving me moral support, money, cooperation, encouragement and also understanding.

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LIST OF ABBREVIATIONS

GA	-	Gait Abnormalities
ABS	-	Acrylonitrile Butadiene Styrene
AFO	-	Ankle and Foot Orthosis
AM	-	Additive Manufacturing
CAD	-	Computer Aided Dseign
CAM	-	Computer Aided Manufacturing
CNC	-	Computer Numerical Control
GLH	-	Gastrocnemius Lateral Head
EMG	-	Electromyography
FO	-	Foot Orthosis
ID	-	Identification Data
KAFO	-	Knee, Ankle and Foot Orthosis
PA	-	Polyamide
PE	-	Polyethylene
NP	-	Normal Patient
PRC	-	Perkeso Rehabilitation Centre
PP	-	Polypropylene
PU	-	Polyurethane
PL	-	Peroneus Longus
PLA	-	Polylactic Acid
RF	-	Rectus Femoris
RMS	-	Root Mean Square
sEMG	-	Surface Electromyography
TA	-	Tibialis Anterior
TPE	-	Thermoplastic Elastomer
TPU	-	Thermoplastic Polyurethane

CHAPTER 1

INTRODUCTION

This chapter gives a brief introduction of project's background based on the general information regarding the gait abnormalities and the objectives of this project. The problem statement, objective and scopes will also be explained in this chapter. Project planning and execution of this project, significant and organization of this project also include in this project.

1.1 Background of Study

Gait is defined as a person's manner of walking, meanwhile abnormalities refer to irregularity of feature or occurrence. Gait abnormalities (GA) is when a person unable to walk in a normal pattern. They faced this complication due to several reasons such as underlying conditions, genetics, injuries, stroke, or problems with the legs and feet. However, intervention as an assistive device produced in order to help in improving the gait abnormalities and capabilities of the post-stroke people as in recovery process. Physical therapy able to help improving a person's gait and reduce their uncomfortable symptoms. One of the physical therapy is by using tool or leg support. Currently, the Gait Abnormality Assistive Device (GUARD) is one of the tool examples, which used to reduce the GA issue, but how far this support device could affect the muscle activity to reduce this issue.

Thus, the functionality of surface electromyography (sEMG) is used to detect muscle function or muscles activity through electrical stimulation. Consequently, the analysis of muscle of people or patient through sEMG was proposed to detect the functionality of an application of current device. The result of this work resulted in confirming the usage of GUARD in reducing the muscle activities and improve fatigue level of the users. This project contributes to society in improving their capabilities and quality of life.

1.1.1 Assistive device

Paramyotonia Congenital (PC) is one of the health problem that contributes to the GA. PC is a significant worldwide medical issue whereby numerous survivors have neglected necessities concerning versatility during recuperation. Thusly, the utilization of automated helped device (i.e., a bionic leg) inside a network setting might be a significant extra to typical physiotherapy in ceaseless stroke survivors (Wright et al., 2018). In order to help the patient with GA, an assistive device has been produced recently. Nevertheless, the functionality of the device has been approved since it is able to be used well on the patient. Somehow, the effectiveness of the device still cannot be determined as there is no statistically evidence or data that the device may help the GA patient. The device is expected to be able to reduce the muscle contraction of the patient during walking and climbing thus can increase the time-to-fatigue of the muscle.

The assistive device mechanisms work basically by distributing to leg load to the hand of the patient in order to reduce the load. Meaning that the load is being shared with the hand. This is because GA patient facing the complications at the leg part, the leg muscle tends to having contractions more than the normal people. So, that is the reason why the muscle of the patient takes shorter time-to-fatigue. This condition will cause difficulties to the patient from doing their daily activities.

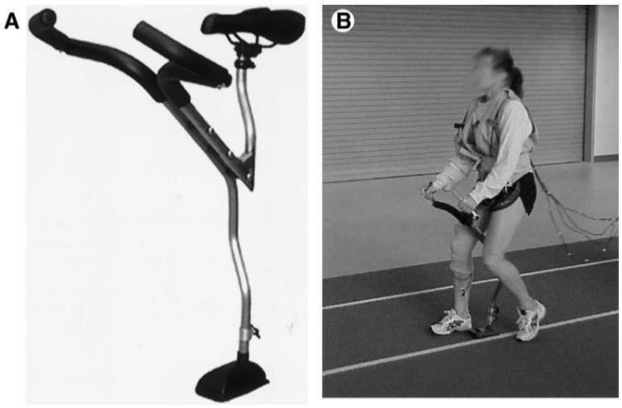

Figure 1.1 assistive device (Wright et al., 2018)

Figure 1.1 above shows an example of assistive device in the year of 2018. The device is being fabricated to help patients with stroke as a post treatment. The device can be found in some rehabilitation centre. For this research, new other device is being used in order to study how the device works for the GA patient. The effectiveness of the device to the patient will be measured throughout this research. Figure 1.2 below shows the device selected.

Figure 1.2 assistive device for GA patient (2019)

1.2 Problem Statement

Hodo (2017) state in his previous study regarding abnormalities of lower leg muscle, varieties in lower leg life structures have been all around archived throughout the years with high-goals imaging modalities, for example, MRI and ultrasonography encouraging recognizable proof of a greater amount of these anomalies. Albeit frequently coincidental discoveries, the distinguishing proof of these variations from the norm can, in specific cases, be clinically critical on the grounds that they can be a wellspring of constant agony, gait irregularities, and injury. Nonetheless, a few variations can be valuable in careful recreation (Hodo et al., 2017). Currently, the Gait Abnormality Assistive Device (GUARD) has been produced in order to reduce the GA issue. Unfortunately, this device has not yet been analysed for its performance on muscle. This device is created to reduce the muscle stretch on leg at the same time increase the comfortability of the patient to walk in a normal condition. This project will begin with the investigating on the muscle activities between the normal people and GA patient then it will continue with analysing the data of the muscle. A specific tool called as Electromyography (EMG) will be utilized in order to get the data.

1.3 Objective

1. To investigate muscle activity and gait analysis of normal people and GA people.
2. To analyse the muscle activity and gait analysis of the assistive device GUARD for GA people.
3. To evaluate the effectiveness of using GUARD to muscle and time-to-fatigue of GA people.

1.4 Scope

This project will focus on investigating muscle activity between normal people in Sekolah Menengah Bukit Baru and patient with Gait Abnormalities in Sekolah Menengah Bukit Baru. It is as well as investigating GA of normal people and GA of PERKESO Rehabilitation Centre patient, both case study located in Melaka. The results of muscle activity towards the Gait Abnormality Assistive Device (GUARD) on the patient are going to be concluded in this project. The device suggested could reduce the amount of muscle contractions in order to increase the gait comfortabilities. This study is being conducted on 3 normal people in average age of 15-24 years old. For the GA patient, since the fabricated product is based on 1 real case study thus the sample number for patient with that rare abnormalities is 1. The patient is 15 years old. The scopes of this project are:

i. Interview are conducted to normal people and GA patient at PRC and SM Bukit Baru.
ii. Perform Muscle test using EMG in order to study the difference of muscle behaviour between normal and GA patient.
iii. Analyse the result obtained from the interview and EMG.

1.5 Organization of The Report

The significant of this study is to assist to the Gait abnormalities patient in order to overcome the gait disorders. Patient with this abnormality are facing complications to deal with their daily activities. The previous study shows that GA patient tend to lose their strength and ability to walk normally when their muscle begins to tired due to continuous stretch and load at their leg muscle. During this situation, patient unable to proceed with their daily activities. This study is expected to able to solve this problem by enable to reduce their uncomfortableness thus reducing their muscle stress. This will be proven by analysing the muscle behaviour of the patient with the Gait Abnormality Assistive Device (GUARD) by using the EMG.

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 project including dated of report submission. This project schedule is presented in Appendix A.

1.7 Thesis Organization

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

- Chapter II. Literature Review: This chapter gives a general classification of Gait Abnormalities (GA), physical effects, and hemiparesis condition in GA, hemiparesis disabilities in term of range of motion and which muscles involve on the affected upper limb part, technique recovery for hemiparesis patient. Apart from that also includes method to evaluate the muscle strength which is manual muscle testing and also the information regarding existing intervention of arm slings and the important of assistive device for patient with hemiparesis condition.
- Chapter III. Experimental procedure: describe the experimental work or procedure involved during product development. This chapter consist of method of data collection, material used, mechanism of the product, experimental analysis, types of software used to analyse the data which is EMG software
- Chapter IV. The process of collecting data more detailed. The result of survey analysis. The discussion in every graph obtained from raw data. The comparison of muscle behaviour between normal and GA patient.
- Chapter V. The sections that will comprise the overall findings and discussion of the project and the recommendation for future works is outlined in this study are presented

1.8 Summary

In this chapter, the general knowledge of gait abnormalities is explained. There are several types of causes can lead to this problem. GA people are having trouble since they cannot be independent to perform daily routine. This project is to study further about the muscle activity of GA people and normal people, the problem statement also briefly explained in this chapter for understanding the purpose of this project. Then, an objective and scope of this study also stated in order to solve the problem statement.

CHAPTER 2

LITERATURE REVIEW

This chapter shows a brief overview from the past researches and studies conducted. All the information obtained is cited to the owner of the study. The previous research is for a guideline to the new project

2.1 Introduction to Gait Abnormalities

In general, GA in patients can be recognized by straightforward strolling tests, in any case, in research centre creatures this is progressively convoluted and a few tests have been created, for example the open field test and impression examination. Here are eight basic pathological gaits that can be endorsed to neurological circumstances: spastic diplegic, hemiplegic, myophatic, neuropathic, choreiform, ataxic (cerebellar), sensory Parkinsonian, and a choreiform. Diagnosis of these gaits are crucial and important aspect of observation as it could provide information regarding neurological and musculoskeletal conditions for GA patients.

2.2 Types of Gait Abnormalities

2.2.1 Hemiplegic Gait

This case happen when patient only have one-sided normal leg but the other side failing or affected. This is not necessary whether inside turned, arm flexed or adducted. The failing side of leg is in extension with plantar flexion of that toes and foot (Evkaya et al., 2020). Patient with this type of gate usually pulls and hold the side of their arm when they are walking in a curved (circumduction) due to the extensor hypertonia in lower appendage and failure of distal muscles (foot drop). Stroke are one of the condition where this type of gait most frequently exist. Figure 2.1 shows the patient with hemiplegic gait.

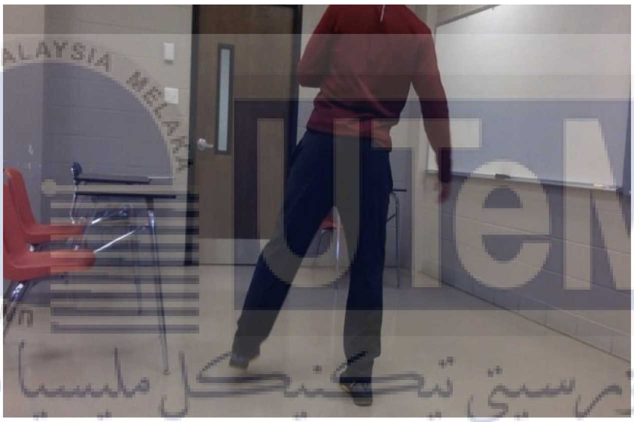

Figure 2.1 Patient with hemiplegic gait (Evkaya et al., 2020)

2.2.2 Diplegic Gait

This type of gait occurred when the both side of legs with spasticity in the minor boundaries is worse than the upper boundaries (Ameer et al., 2019). Due to the scratching toes and carrying the two problematic legs the patient will have a strangely inadequate base during walking. Those who suffered from this gait are respective periventricular sores. Diplegic gait with an appropriate clinical concern could have hip adductor to reduce the scissoring. Figure 2.2 shows the diplegic gait pattern that occur in children.

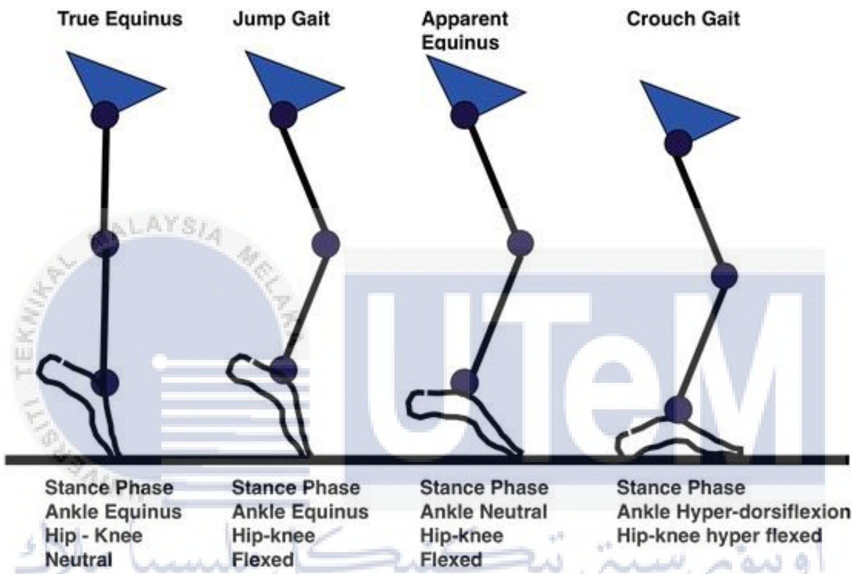

Figure 2.2 Diplegic gait pattern in children (Ameer et al., 2019)

2.2.3 Neuropathic Gait (Steppage Gait, Equine Gait)

The reason why this gait happen is because of an endeavour in lifting the leg adequately high while walking thus the foot cannot remain stay on the floor. In one sided cases, integrate peroneal nerve paralysis and L5 radiculopathy also can happen (Gorostidi et al., 2015). This type of case can usually be found in patients with foot drop (foot dorsiflexion failure). In common occurrence, this case lead to integrate amyotrophic sideways sclerosis.

2.2.4 Myopathic Gait

During walking, muscles that supported by hip are liable and in charge for the pelvis level. In this case, the patient will have the failure on one side which will rapidly drop the pelvis on the side of contralateral when the patient walking (Trendelenburg sign). With the one sided failure, the pelvis on the two sides drop during swaying, prompting and walking (Hwang, 2016). Generally, this type of gait is found in tolerant with myopathies, for example, solid dystrophy. Figure 2.3 shows the example of myopathic gait.

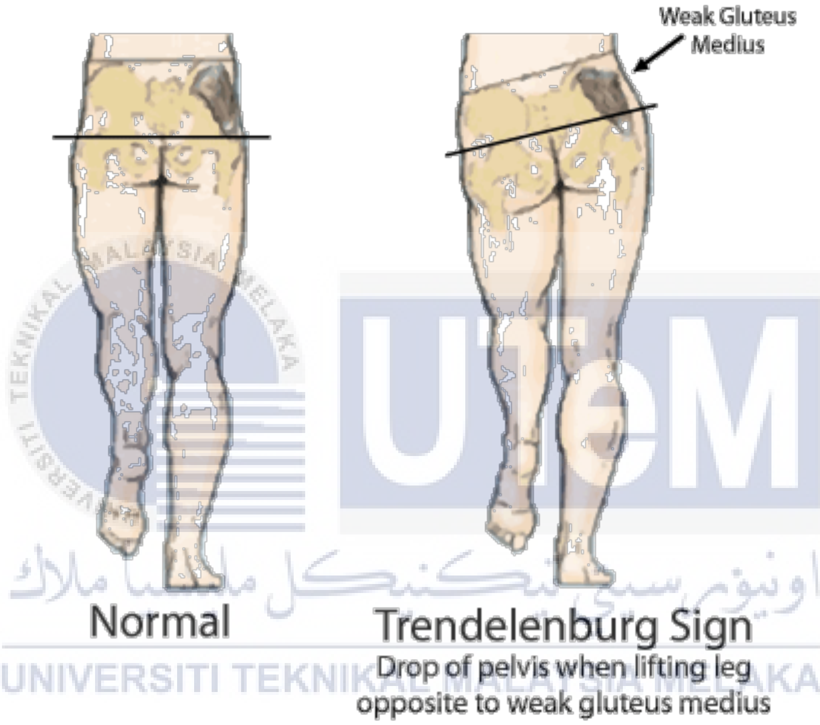

Figure 2.3 Myopathic Gait (Wolburg et al., 2016)

2.2.5 Choreiform Gait (Hyperkinetic Gait)

This gait is seen with certain basal ganglia issue including Huntington's Disease, Sydenham's chorea and any other various types of dystonia, athetosis, or chorea (Gorostidi et al., 2015). This patient will show sporadic, jumpy, and automatic developments in every related limits. Strolling could highlight their gauge development issue (Ameer et al., 2019).

2.2.6 Ataxic Gait

(Cerebellar)

This type of gait is usually found in the cerebellar sickness, and it is represented as stunning, awkward, progresses with a wide-based gait. The patient's body may strut to and fro and from one side to another side which called as tattering while standing still (Hwang, 2016). Patients would not have the option whether to turn from toe to heel or in an orderly fashion. Usually the patient that have more truncal precariousness tend to get midline malady cerebellar at their vermis(Gorostidi et al., 2015). Figure 2.4 below shows the common detections in ataxia gait in patient.

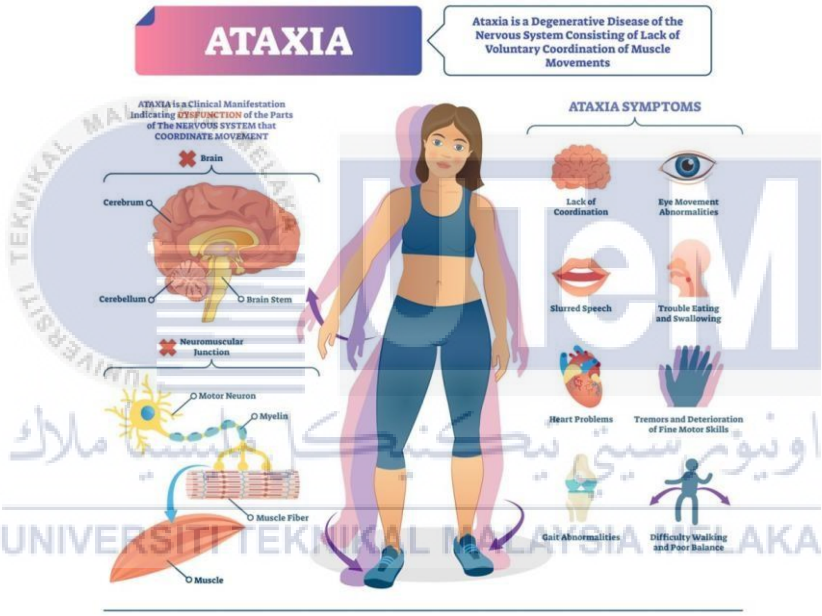

Figure 2.4 Common detections in ataxia gait patient (Serrao et al., 2018)

2.2.7 Parkinsonian Gait

The patient suffered from gait, are going to also suffered from bradykinesia and unbending nature. The patient is going to bent while the neck the head forward, with the knees flexion. All of the furthest point is added in flexion with the fingers are normally extended (Gondim et al., 2020). The patient also possessed a tendency automatically in order to make the strides quicker and this is known as festination.

2.2.8 Sensory Gait

When the feet start reaching and have a contact to the ground, it tends to get proprioceptive information to reveal that particular area. This type of tactile ataxic gait occurs when the proprioceptive info is existed (Matsuda et al., 2016). Most important, the worsening condition is when the patients cannot even see their feet (for example in inconspicuousness). The gait may additionally some of the time indicated to as a walking gait since patients can lift their legs higher in order to hit the ground more (Hwang, 2016). This type of gait can be observed in disorders of the dorsal sections (B12 insufficiency or sexually spread sickness) or in infections persuading the fringe nerves (uncontrolled diabetes). For more serious structure, this gait can lead to an ataxia which looks similar like the cerebellar ataxic gait.

2.3 Psychophysical Experience

Psychophysical experience is a method that estimates acceptable load under the variety of force, repetition, posture, and period conditions. It quantitatively investigates the relationship between physical stimuli and sensations and perceptions (Ciriello, 2008). The previous study also identified the assistive device design more effective than standard chair. This method can achieve quantitative assessment of posture under different condition. Therefore, assistive device improved an objective measure of comfort in healthy individual and GA patients (Grondin et al., 2016). Another factor that can contribute to comfort is thermal influence due to the interaction between human and the seating surface. A psychophysical approach in this study is to evaluate the thermal influence of the tack chair on the seat pan temperature (objective variable) (Kumar et al., 2015). Different types of psychophysical experience will be elaborated in sub-section later.

2.4 Biomechanical

Biomechanical is the mechanics as it relates to the functional and anatomical analyses of the biological system and related to human. This study will point out some biomechanics factors such as muscle fatigue, heart rate, and ergonomic posture. Biomechanical modelling is right to be the best method in establishing acceptable loads in forwarding flexed posture and providing the realistic assessments of different spinal loadings that occur in lumbar (Gallagher and Hamrick, 1991).

2.5 Surface Electromyography

The surface electromyography (sEMG) was used to measure muscle activity and muscle fatigue. It analyses the electric signals that are displayed from contraction muscles (Murthy and Khan, 2013). The sEMG is non-invasive and it performs a real-time fatigue monitoring during the performance of defined work. Otherwise, it can also monitor the fatigue of muscle that is highly correlated with biochemical and physiological changes in muscles during fatiguing.

The wireless sEMG provides more application possibilities than the traditional sEMG system, such as the dynamic monitoring of specific human muscle (Chang et al., 2012). Therefore, the wireless sEMG is suitable for industry experiment compared to the traditional system in obtaining accurate signals based on the environment of subjects.

Muscle contraction starts when the nervous system generates a signal and this signal is called impulse that travels through the nerve cell (motor neuron). A chemical message is released by the motor neuron and binds to receptors on the outside of the muscle fibre. This stage starts a chemical reaction within the muscles (Visible Body, 2014). Figure 2.13 shows the muscle reaction and contraction during working.

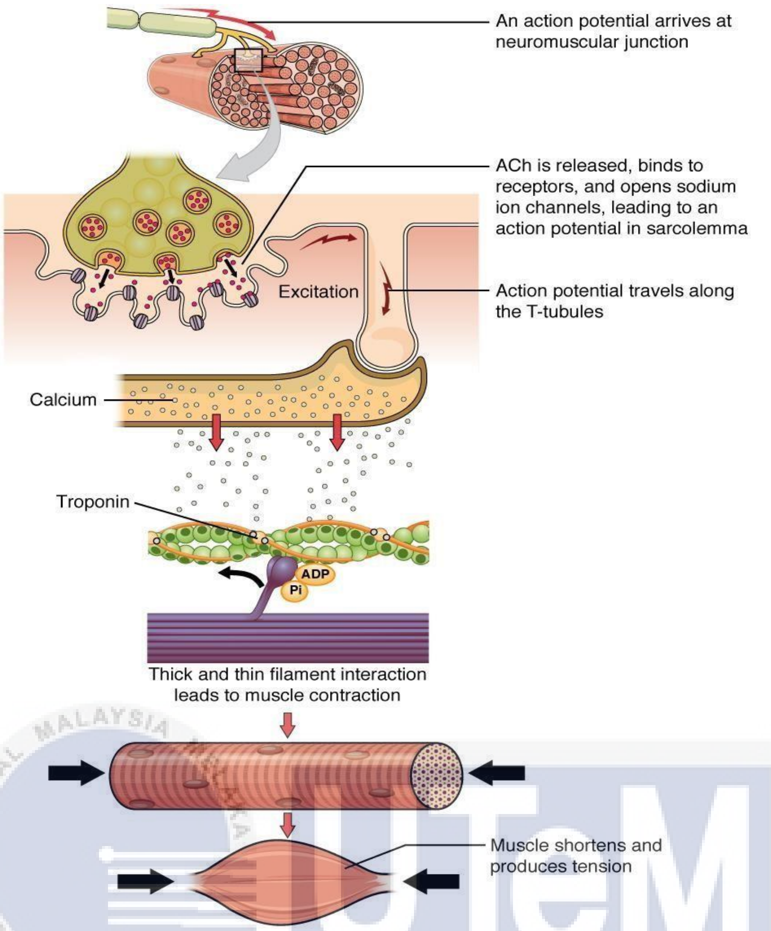

Figure 2.5: The contraction of the muscle (Delsys Inc, 2019)

During the contraction and relaxation of muscles, electrical signals in the nervous system are continuously sending the message. The very small magnitude of the electrical signal is carried to the different parts of the body. An electrical charge is jumping from one cell to another until reaches its destination (Docsity, 2013). Therefore, sEMG is used to measure muscle response or electrical activity in response to a nerve’s stimulation of the muscle. The test is used to help detect neuromuscular abnormalities through the skin into the muscle. sEMG detects the electrical activity of muscle during rest, slight contraction, and forceful contraction; however, muscle tissue does not normally produce electrical signals during rest (Johns Hopkins Medicine Health Library, 2019).

2.5.1 Delsys Trigno Wireless EMG

Electromyography (EMG) is known as one of the technique of measuring electrical activity that produced by muscles during rest or contraction. The electrical signal generates from the brain and sends to the muscles via motor neuron (Gupta *et al.*, 2017). The dysfunctional of the muscles or failure in signals transmission from nerves to muscles can be detected by EMG. The electrical stimulation from the external source to muscles is required for the failure of sending the electrical signal from the brain to the conducting nerves. The signal detection of electrical activity in muscles is using electrodes of the EMG. Figure 2.5 shows Delsys Trigno Wireless EMG that can be used to evaluate muscle fatigue.

Figure 2.6: Delsys Trigno Wireless EMG (Delsys Inc, 2019).

2.5.2 Muscular System

Wan (2015) point out that the movement of the human body are responsible by about 700 muscles. Each of the muscles are discrete organ constructed of skeletal muscle tissue, blood vessels, tendons and nerves. There are three types of muscles that human have which includes smooth, cardiac and skeletal. All the daily activities including, talking, walking, sitting, standing and running require movement of particular skeletal muscle. Even when sleeping, the skeletal muscles are used.

2.5.3 Lower limb muscles

Parker (2019) defines the muscles that move the feet and toes are known as lower limb muscles which divided by three categories including anterior, lateral and posterior. Muscles are responsible to generate the required force for any movement whether it is simple or aggressive. It can be carried out by respectively in contracting mechanism. In a continuous contracting process, muscles can be slowly and gradually entering into the state of fatigue. Fatigue is a main calculation that will be focused in this study in obtaining the behaviour and time to fatigue of the muscle. This is important to show and predict the effect of device and assisting tool to reduce the muscle fatigue.

From literature searches, fatigue is known as a feeling of tiredness, exhaustion or a condition that need a rest caused by the lack of energy from the repetitive work. (Wan, 2015). Muscles can become torn or strained if it overworks or overstress. Commonly, strains known as pain with the presence of movement or pressure. Figure 2.17 shows the lower limb muscles with it functions that normally be the main muscles for EMG muscle fatigue evaluation has been stated by Parker (2019).

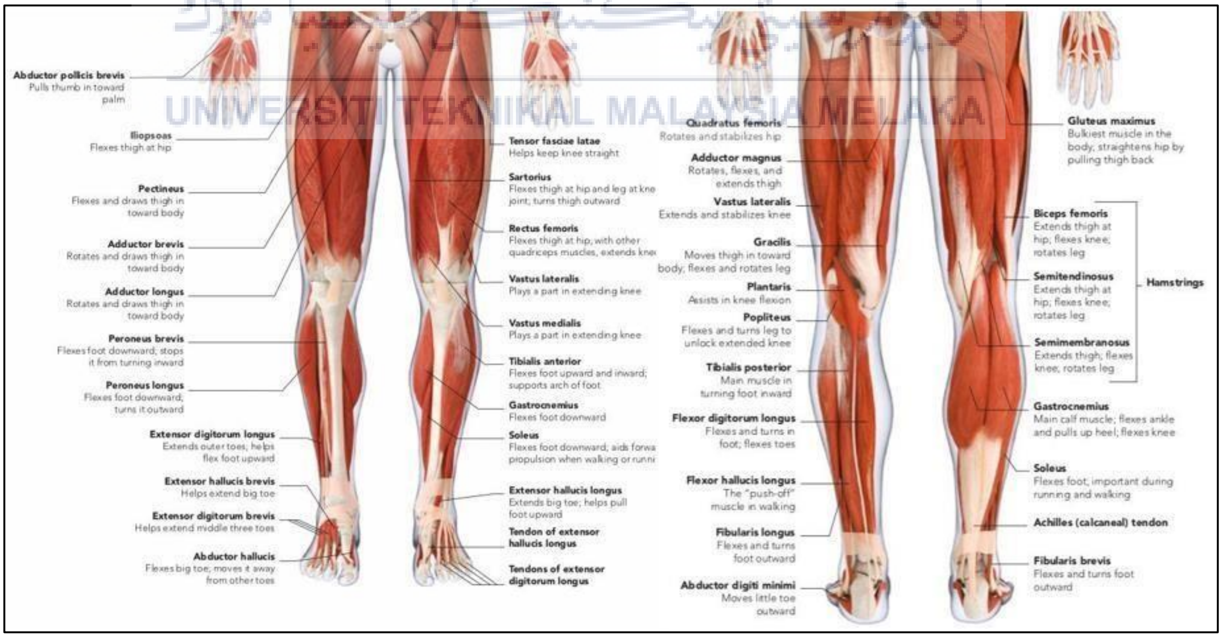

Figure 2.7: The lower limb muscles with its functions (Parker, 2019).

Other than that, in summary, Table 2.1 below shown a descriptive summary of previous researchers work of muscle involved during EMG testing for the evaluation and analysis of the muscles.

Table 2.1: A descriptive summary of examples in the literature review about the muscles involve during EMG testing for muscles fatigue evaluation.

Author	**Muscles**	**Activity**
Paul *et al.*, (2019)	Tibialis Anterior (TA) Peroneus Longus (PL) Soleus (S)	Walking
Umi Hayati *et al.,* (2019)	Tibialis Anterior (TA) Gastrocnemius (G) Rectus Femoris (RF)	Running
Park & Park, (2018)	Tibialis Anterior (TA) Abductor Hallucis Longus (AHL) Peroneus Longus (PL)	Walking
Lee *et al.*, (2013)	Abductor Hallucis (AH) Medial Gastrocnemius (MG) Ttibialis Anterior (TA) Vastus Medialis (VM) Vastus Lateralis (VL) Rectus Femoris (RF)	Standing

2.6 Research Gap

Previously, there are a lot of studies and research regarding muscle activity and utilized the EMG tools. However, there is no study yet regarding how the muscle activity on GA patient with the assistive device. That is why this project is conducted. Table 2.2 below shows the summary from the past research. The research is basically from (Akuzawa et al., 2017), (Farahpour et al., 2018), (Hill et al., 2019), (Felicio et al., 2019), (Nakai et al., 2019), (Marshall et al., 2020), (Rozanski et al., 2020), (Roca-Dols et al., 2018).

Table 2.2: Summary of research gap

Author/ Title	Objective/ Scope	Method	Finding	Limitation / Gap
(Marshall et al., 2020) Quadriceps muscle electromyography activity during physical activities and resistance exercise modes in younger and older adults	To determine whether indices of quadriceps muscle EMG activity in response to different modes of RET and activities of daily living (ADL), differed between 15 healthy younger (25 ± 3 years) and 15 older (70 ± 5 years) adults	-participants completed a maximal voluntary contraction (MVC) of the knee extensors -walking task 15m, stair climbing task lower-limb RET through body-weight squats (BW-RET)	EMG activity during all exercise tasks was significantly higher in older vs. younger adults when expressed relative to maximal EMG achieved during MVC	there was no significant difference in quadriceps EMG between EB-RET and MN-RET ($P > 0.05$)
(Nakai et al., 2019) Trunk muscle activity during trunk stabilizing exercise with isometric hip rotation using electromyography and ultrasound	To clarify the muscle activation during trunk stabilizing exercise with isometric hip rotation in healthy males by comparing that with abdominal crunch (AC) and active straight leg raise (ASLR)	-Muscle activity was normalized to maximum voluntary contraction (MVC), and muscle thickness normalize to resting muscle thickness. -Experiment test using surface EMG (sEMG)	Muscle activation and thickness of IO, MF and TrA increased significantly during the isometric hip rotation compared with other exercises. Muscle activation during the trunk stabilizing exercise with ipsilateral isometric hip	may be used for the prevention and treatment of low back pain

(Rozanski et al., 2020) Lower limb muscle activity underlying temporaly gait Asymmetry post- stroke	To investigated electromyography (EMG) features of temporal gait asymmetry (TGA)	-Self-paced for participants' poststroke with or without TGA and plate -Experiment test using surface EMG (sEMG)	The TGA group exhibited fewer dorsi- flexor bursts during swing	Neuromuscular underpinnings of spatiotemporal asymmetry have not been previously characterized. These novel findings may inform targeted therapeutic strategies to improve gait quality after stroke
(Hill et al., 2019) The Interaction of Cognitive Interference, Standing Surface, and Fatigue on Lower Extremity Muscle Activity	To assess lower extremity muscular activity during erect standing on three different standing surfaces, before and after an acute workload and during cognitive tasks	Experiment test using surface EMG (sEMG) ankle 15 sample taken.	Pre-workload muscle activity did not differ between surfaces and cognitive task conditions	Cognitive task errors did not differ between surface and workload
(Felicio et al., 2019) Electromyography activity of the quadriceps and gluteus medius muscles during/different straight leg raise and squat exercises in women with patellofemoral pain syndrome	To analyse the electromyographic activity of the quadriceps and GMed muscles during different open and closed kinetic chain exercises in individuals with and without PPS.	Experiment test using surface EMG (sEMG) Experiment test using laboratory equipmnets	SLR and SLR-LR exercises generated the highest simultaneous activity of the GMed and quadriceps muscles in both groups	not stratified into patients with weak quadriceps muscles therefore, anterior knee pain symptoms were considered lack of measurement of pain levels in individuals in the PPS group during the various activities performed
(Roca-Dols et al., 2018) Electromyography activity of triceps surae and tibialis anterior muscles related to various sports shoes	To evaluate the activity patterns of TS and TA muscles in healthy people during all gait phases using five types of sport shoes with respect to barefoot condition	-Health questionnaire. -Physical exam. Laboratory studying for lifting movement.	Gastrocnemius muscle activity increased with the use of minimalist and boost sport shoes with respect to barefoot condition	The muscle activity pattern of leg muscles may be altered under ankle chronic instability conditions

(Farahpour et al., 2018) Muscle activity and kinetics of lower limbs during walking in pronated feet individuals with and without low back pain.	To investigate whether excessive feet pronation alters the joints' kinematics, kinetics and the activity of involved muscles during gait in low back pain patients	-Mesure the lower limb joints' motion, moment and power, as well as the activity of involved muscles during walking	Reveals that strengthening of the muscles especially knee extensors are of great importance in low back pain patients with feet pronation	Not possible to conclude whether the excessive muscle activity is cause or the consequence of the LBP
(Akuzawa et al., 2017) The influence of foot position on lower leg muscle activity during a heel raise exercise measured with finewire and surface EMG	To examine the influence of foot position on lower leg muscle activity during heel raises	-Laboratory -One-way repeated measure ANOVA was employed for statistical analysis.	TP, PL and FDL was significantly different between the three foot positions during the heel raises.	Might be not sufficient for participants to achieve maximum contraction of muscle.

2.7 Summary of The Literature Review

In this chapter, the topic was discussed is about the review of previous research and paper. Every information related to this project is being reviewed in this chapter. The previous methodology, the method used in this project and also some of the limitations obtained by the previous research. In the next chapter will proceed with the flow of the project which is methodology.

CHAPTER 3

METHODOLODY

This chapter will discuss the flow from the beginning till the ending of the project will be elaborated in details. The needs of this chapter is because the research methodology gives technique and solution flow in solving the problem. It also provides the tips on how to choose materials, systems, methods, scientific tools, and training in techniques according to the problem chosen. Every selected method will be justified in this chapter

3.1 Overview of project

Figure 3.1 represents the overall flow of this research towards muscle activity with the assistive device. The figure shows the planning of project and development process flow and illustrates the relationship between the different stages

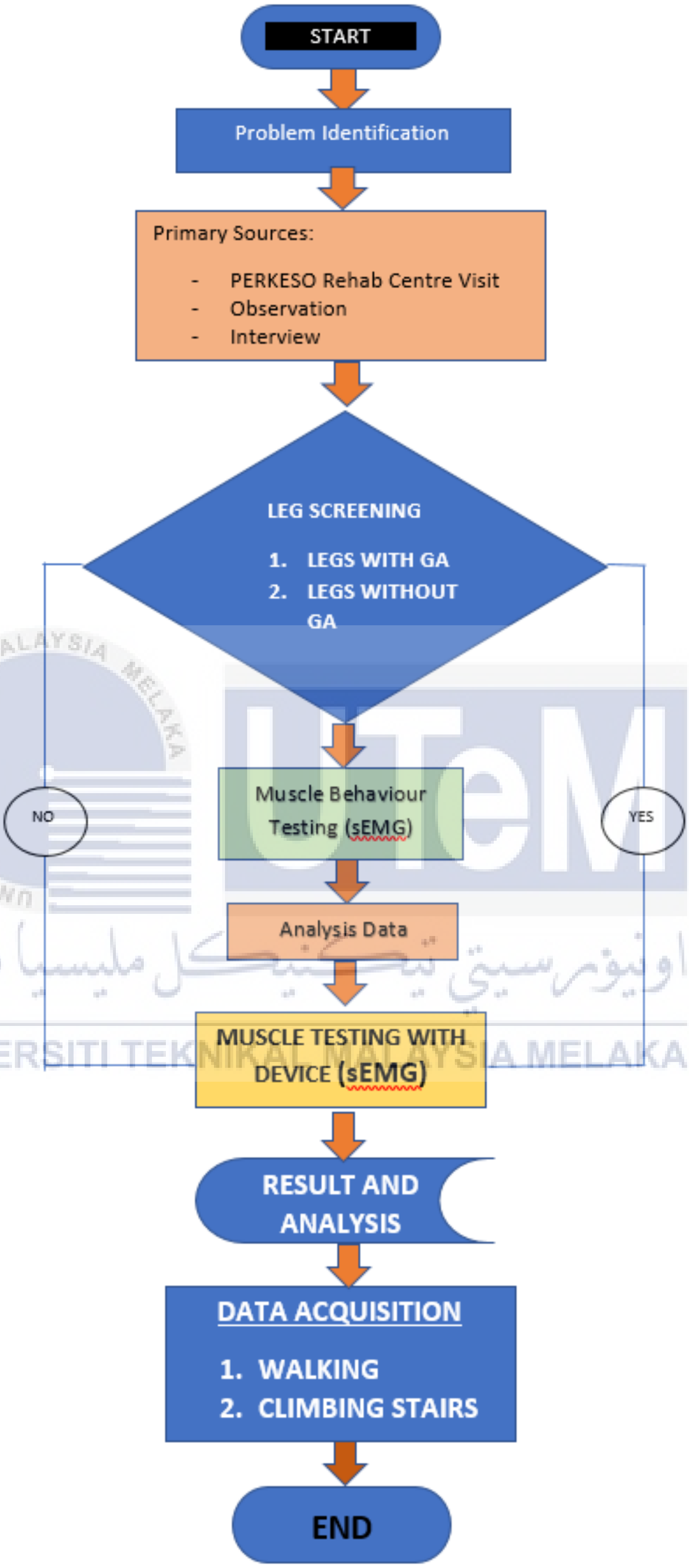

Figure 3.1: Research Flowchart

Based on the Figure 3.1, this project begins with problem identification which is identify what is the major problem for this issue in order to figure out the solution before start making review and study for the previous related research. Then, continue with the primary sources which is where the sample is taken. For this project, the location involved in this action is at the Sekolah Menengah Bukit Baru and PERKESO Rehabilitation Centre. This place consists of patient with that suffered from a few types of Gait Abnormalities (GA). After that, the screening process begins for the person with and without GA. The test for the first pilot result is taken and analysed. This is to investigate the muscle behaviour of both type of people. The patient with GA is the identified to proceed with Electromyography (EMG). This test is to achieve the second objective which is to study the muscle activity of the patient with and without the Gait Abnormality Assistive Device (GUARD). The results obtained from the EMG tools is then being analyzed and compared with each type of muscles. Since the test is run for two types of condition, walking and climbing stairs thus the data acquisition is being done for both. So that is the end of the project. The result is expected to be positive, which is the muscle stress is reduce with the help of Gait Abnormality Assistive Device (GUARD). The testing is being repeated for three times and the average value is being calculated. For GA patient, due to the health condition, the testing is being done once only as the muscle of the patient is begins to fatigue. It cannot be repeated three times as normal people. The formula to calculate the percentage RMS of muscle reduction (%) is given as below.

A = RMS value with the device

B = RMS value without the device

Percentage RMS of muscle reduction (%) = $\frac{B-A}{B} X\ 100$

Equation 3.1

3.2 Relationship Between Objectives and Methodology

Summarize the relationship between the objectives stated with the methodology on how the process will going in order to achieve the target. The tools use in the methodology also stated in table 3.1.

Table 3.1: Relationship between objectives and methodology

OBJECTIVES	METHODOLOGY	TOOLS
1. To investigate muscle activity and gait abnormality of GA people.	• Interview • Questionnaire • Muscle behaviour	Proper interview Pilot survey Questionnaire
2. To analyse the Muscle Activity and Gait Analysis of the Assistive Device for Gait Abnormalities Patient	• Muscle activity • Muscle stress • Interview	EMG tools Survey
3. To evaluate the effectiveness of using GUARD to muscle to improvement and time-to-fatigue of GA people	• Interview session • Muscle behaviour	Interview EMG tool Microsoft Excel

3.3 Developing Interview Question

The interview question is used as a medium to collect data on the factors and physical experience that contribute to the respondent needs. The following section describes the interview question used during the survey development that easy to classify the needs to be improved in products (Viegas et al., 2016). Roy et al. (2017) stated that customer satisfaction and perceived risk can overcome the dependency on customer experiences and payback variables. Therefore, the product is focused on customer's needs a fact, based on justification, and there is no critical customer's need is missed. These questionnaires on current product or view can fulfil the needs of the customer for future usage due to the knowledge of differentiating the best product, the required needs, and the gaps of existing and new products in the future (Whitehead et al., 2016). Based on the Figure 3.3, below are the question given to the respondent during interview.

3.3.1 Interview Question

Interview question is being generated to the respondent in other to gain the information. It also gives opportunities to assess the data such as demographic and the requirement specifications of assistive device from the respondent. The question consists 2 part which are part A and part B. Part A question regarding the demography meanwhile Part B question related to the respondent specifications. Figure 3.4 and figure 3.5 shows the interview questions.

PART A: BACKGROUND OF RESPONDENT

Please answer the following questions.
Sila jawab soalan-soalan berikut.

1. Name / *nama*: ___________________________

2. Date of answering survey / *tarikh menjawab soalan kajian*: __________

3. Nationality / *warganegara:* ________________

4. Age / *umur*: a) 13-19 ◯ b)20 to 29◯ c)30 to 39 ◯ d)40 to 49◯

   e) 50 and above ◯

5. Gender / *jantina*: Male◯ Female◯

6. Height / *tinggi*: _________cm

7. Weight / *berat*: _________kg

8. How long have you suffered with this disease? / *sudah berapa lama anda menghidap penyakit ini?* ________________

Figure 3.2 section A of interview question

PART B: RESPONDENT SPECIFICATIONS

SPECIFICATION	
Gender	
Age	
Height	
Weight	
BMI	
Characteristic (Medical history)	

Figure 3.3 section B of interview question

3.4 Experimental Plan

Experimental plan is characterized as a part of applied insights that manages arranging, directing, investigating, and deciphering controlled tests to assess the components that control the estimation of a boundary or gathering of boundaries. Experimental plan is an amazing information assortment and examination device that can be utilized in an assortment of exploratory circumstances.

It considers different info variables to be controlled, deciding their impact on an ideal yield (reaction). By controlling numerous contributions simultaneously, Experimental plan can recognize significant communications that might be missed while exploring different avenues regarding each factor in turn. Every conceivable mix can be explored (full factorial) or just a segment of the potential blends (partial factorial).

A deliberately arranged and executed investigation may give a lot of data about the impact on a reaction variable because of at least one elements. Numerous analyses include holding certain components steady and changing the degrees of another variable. This way is to deal with process information, be that as it may, wasteful when contrasted and changing component levels at the same time. Table 3.2 below shows the illustration of experimental plan for the experimental setup from the beginning till the ending of experiment.

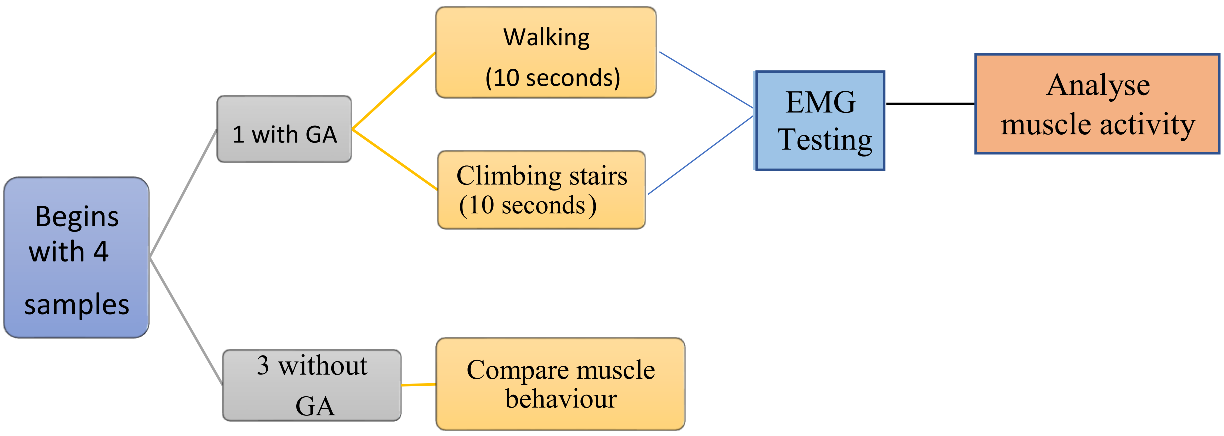

Figure 3.4 Illustration of experimental plan

.

Table 3.2: Experimental plan for muscle activity experiment in layup process (confidential process)

No.	Time of process (min)	Activity For Layup Process	Description
1.	3	Walking	Patient with GA need to put on the assistive device and walk for 10 seconds.
2.	1	Climbing stairs	Patient with GA need to put on the assistive device and climb stairs for 10 seconds.

3.5 Anthropometry data

The field anthropometry comprises a variety of human body measurement of height, weight and size, including circumference, length and breadth of human figures. Anthropometry is considering as analysis and application of human body dimensions or generally physical measurement to the design and assessment of workspaces, product and tools where enable the people to interact. The data is very important in human factors/ergonomics application and most important part of this application is to ensure that the design follows the user population sizes of to be more standard and realistic ("Anthropometric Reference Data for Children and Adults: United States," 2010). As we can see from Figure 3.2 below shows the example of anthropometry dimensional parameter:

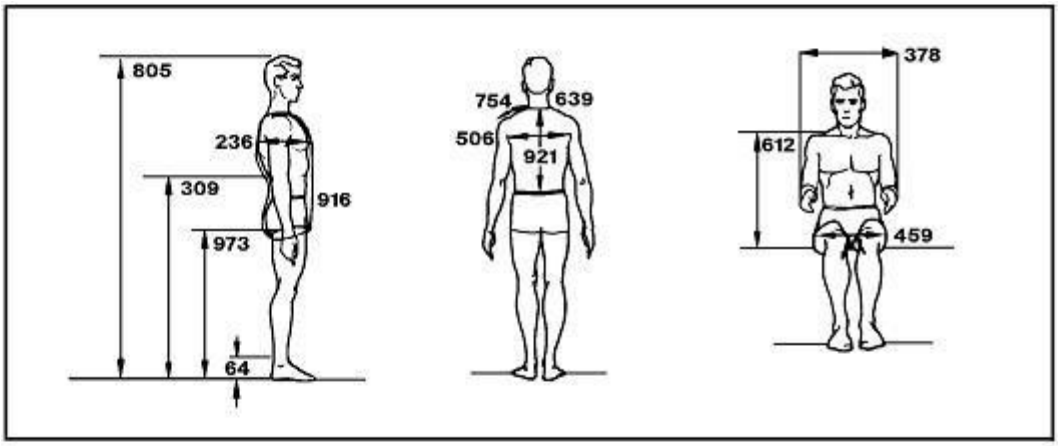

Figure 3.5: Anthropometric Dimensional (Man, 2013).

3.5.1 Percentile of Anthropometry Data

The percentile range in anthropometric data is important to design and sizing of the workspace and product in order to ensure accommodation, compatibility, functionality and maintainability. Basically there are three types of percentile which is 5^{th}, 50th and $95^{th.}$ Each percentile refers to the different type of people size. As for the 5^{th} percentile refer to small size people, the 50^{th} percentile indicates the average dimensions and 95^{th} percentile refer to tallest or biggest size people dimensions (Man, 2013). Hence, to decide the percentile value that used in the design depends on the type of the design and most important is to justify who is the user of the product.

3.5.2 Measurement Tools of Anthropometry Data

Anthropometric measurements are used to gather the data of size, shape and composition of human body ("Anthropometry Procedures Manual," 2007). In this project, the equipment tool involves during the taking of the anthropometry measurement data of nine participants in PRC centre is body measuring tape, body measuring tape, large anthropometer, small anthropometer, circumference tape. In the figure 3.4 shows the equipment tools that is used to gather the anthropometric measurement in PRC centre.

Figure 3.6: Measurement equipment of anthropometric data (body measuring tape, circumference tape, large anthropometer, measuring tape, small antropometer).

3.6 EMG Signal Acquisition Process

Electromyography (EMG) testing is conducted in this study in order to evaluate the muscle fatigue on subject who suffers from flat feet. The EMG testing is conducted by instructing subject for EMG signal acquisition of what repetitive activities need to be done The following steps is shown in Figure 3.7 and the step description details will be explained further.

Figure 3.7: Steps of electromyography testing of GA patient. (EMG manual, 2017)

3.6.1 Instructing Subject for EMG Signal Acquisition

Table 3.3: The specification of the subject need to fill on

SPECIFICATION	
Gender	
Age	
Height	
Weight	
BMI	
Characteristic	Patient with GA

3.6.2 Skin Preparation

The sEMG used for this study was DELSYS Trigno Wireless EMG System that functions as a device in collecting electrical signal and filter software that interpreted the signal to a graph. This device is easier and simpler in filtering the data. Akin et al. (2004) stated that the subjects provided feedback in the visual of their rectified sEMG amplitude via computer monitor and DELSYS (EMGworks Signal Acquisition and Analysis Software). DELSYS Trigno was used to test algorithms with data collected from the specialised myographic setup. From the test, the results show that the recognition system displays high accuracy on the data from Trigno and MYO systems. Both systems demonstrate equal accuracy despite significant sampling rate differences (Lobov et al., 2015). EMG sensor can be used as a probe without skin preparation or adhesive. In order to assure the optimal signal detection of EMG sensor once the final location is determined, skin preparation is needed. The steps of skin preparation are as follows:

1. Wipe the surface of the skin, sensor and the silver bars with an isopropyl alcohol pad to remove oils and surface residues.
2. Allow the skin and the sensor to air dry for a few seconds.
3. If necessary, shave excessive hair from skin at the detection site.
4. Apply the sensor to the skin at the prepared site using a Delsys Adhesive Sensor Interface which are for single use only as shown n Figure 3.9.

Figure 3.8 Delsys Adhesive Sensor Interface (Delsys Inc, 2019).

Before starting the experiment, the subjects' hair at the selected muscles area was shaved first and rubbed with alcohol-acetone. This was done to improve the conductivity of electrodes (Kumar and Prasad, 2010). Then, the electrodes were attached to the muscles so that the muscle activity signal can be collected. The subject was required to rest the body about 3 to 5 min before the experiment started (Kumar and Prasad, 2010 and Kang et al., 2013).

3.6.3 Identification of muscles

The primary muscles involved in this project as shown in Figure 3.10 is determined based on the previous research in Chapter 2. Table shows the details description about the muscle involve, function of each muscle and the activity can be done related to the muscles.

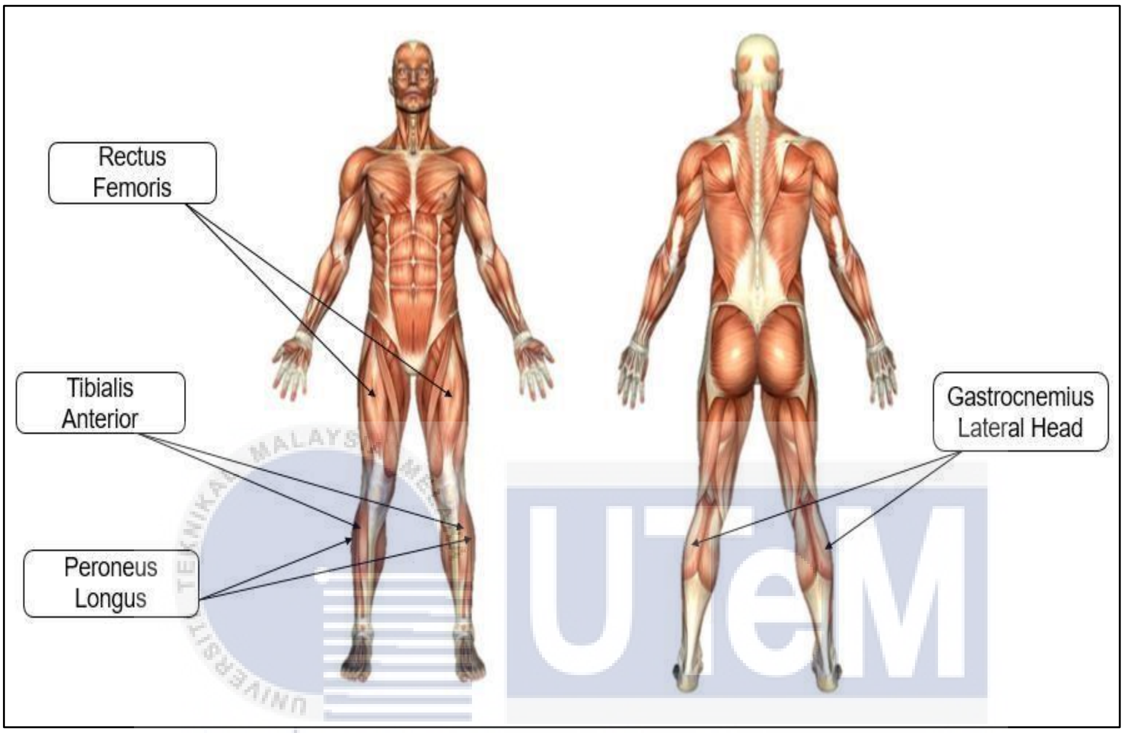

Figure 3.9 Primary muscles involves for EMG testing.

(Parker, 2019)

Table 3.4: Details description of muscles

Muscles	Function	Activity
Tibialis anterior (TA)	Flexes foot upward and inward, support arch of foot	Standing Walking Running Climbing
Rectus Femoris (RF)	Flexes thigh at hip with other quadriceps muscles, extend knee	Walking Running Climbing
Peroneus Longus (PL)	Flexes foot downward, turns it outward	Running Climbing
Gastrocnemius Lateral Head (GLH)	Flexes ankle and pulls up heel, flexes knee	Running Climbing

Table 3.4 above shows the function of the selected muscles. All of the muscle selected are involve directly when a person walking and climbing. Thus, that is why the Delsys EMG sensor is located to the muscles.

3.6.4 Sensor placement

In order to detect a good quality of EMG signals, a proper Trigno EMG sensor location is important. The identification of muscles required is compulsory to determine the precise location and function of the muscle being studied as well as any nearby muscles that may produce undeniable signals or known as crosstalk. The EMG signal is detected at the skin surface by the Trigno EMG sensors that are fitted with 4 silver bar contacts.

The orientation of these bars be perpendicular to the muscle fibres for the maximum signal detection was takes into consideration during sensor placement as shown in Figure 3.11. To aid in the determination of the orientation, the top of sensor is shaped with an arrow which should be placed parallel to the muscle fibres underneath the sensor. The sensor also need to be placed in the centre of the muscle belly, away from tendons and the edge of the muscle. Figure 3.12 shows the sensor placement on the subject’s feet.

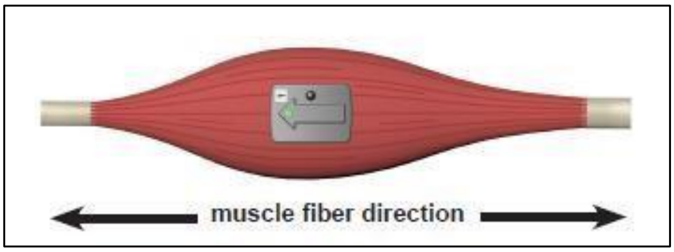

Figure 3.10 The orientation of sensor on muscles (Delsys Inc, 2019).

Figure 3.11 Sensor placement on the subject feet ((a)-front, (b)-back, (c)-side).

3.6.5 EMG signal acquisition

The subject was instructed to walk, run and climb stairs barefoot and with customised TPU orthotic insole when the EMG data were collected as shown in Figure 3.13. The EMG data were recorded for 30 seconds, three times for each activity with a 60 seconds break in between in order to prevent fatigue. The EMG signal are collected via the Delsys EMGwork Acquisition software. The data acquisition will proceed according to the 'Test Configuration' after clicking the Play button in the Test Control window. The dataflow of the signal acquisition during the test is shown in Figure 3.14.

Figure 3.12 The data flow of the signal acquisition during the test.

The EMG signal processed through the Delsys EMGwork Analysis software where the signals are sampled at 1000 Hz. The noise resulting from the surrounding will be filter by removing it from the raw signals. The high-pass filter with a cut-off frequency in the 15 to 20 Hz. Meanwhile, the low-pass filter with a cut-off frequency in the 500 to 1000 Hz range. Thus, all the raw signals collected were filtered with band pass filter range from 50 – 500Hz with second order Butterworth filter.

The time domain analysis of amplitude with root mean square (RMS) were analysed. The RMS is the square root of the mean over time of the vertical distance of the graph from the rest state. Hence, it been used to quantify the electrical signal because it reflects the physiological activity in the motor unit during muscle contraction. Figure 3.15 shows the raw RMS signal on one of the activity of all muscles.

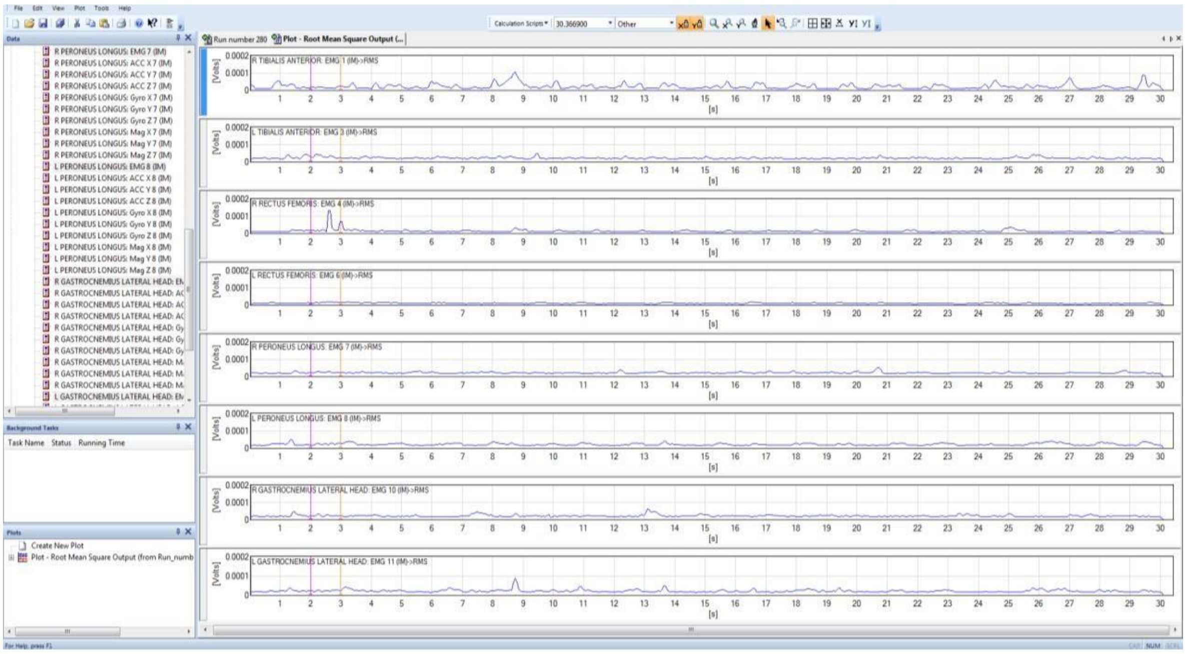

Figure 3.13 The raw RMS signal on one of the activity of all muscles

3.7 Preliminary Result

Preliminary result is a result obtained from the pilot study. The result is from GA people assist with the GUARD. The result need to be done in more details as the average result from the samples should be calculated to ensure the data is more compatible.

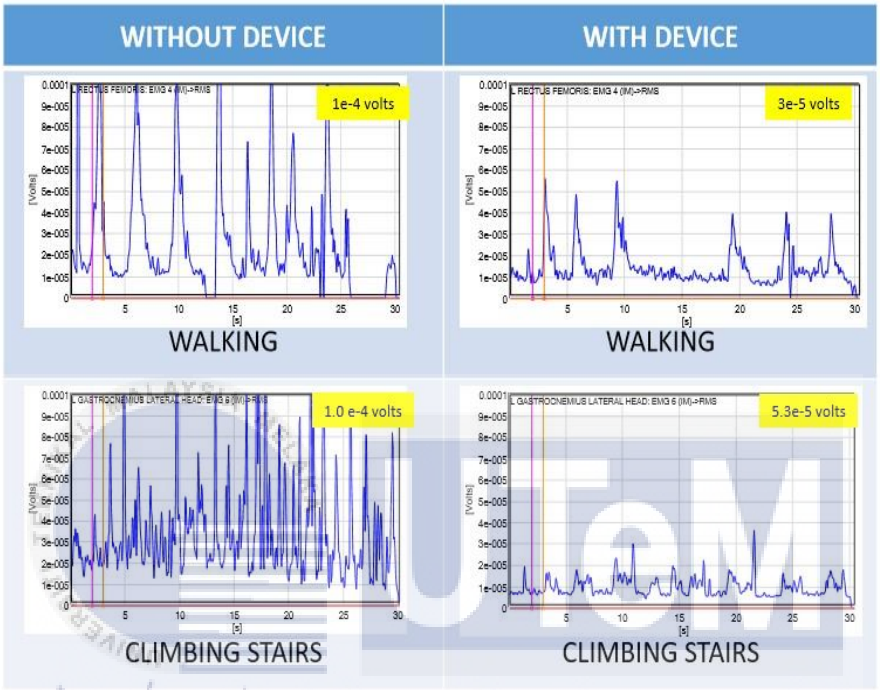

Figure 3.14 Preliminary result

3.8 Summary of Methodology

The methodology and exploration stream are laid out and expounded in this segment. The methodology of the examination was characterized plainly on how the targets of the exploration could be accomplished during this exploration. The methodology and targets should be adjusted together to help the analyst in delivering a right and exact outcome and examination.

CHAPTER

RESULT AND DISCUSSION

This chapter describes the result and discussion from the muscle testing for normal people and GA patient. All the data obtained is being analysed and discussed in details in this chapter. The effectiveness of the device is measured through the reduction of muscle contraction and the time-to-fatigue.

4.1 Muscle activity analysis

This section discussed the muscle activity of the normal people and GA patient while walking and climbing stairs. The muscle contraction was identified through this analysis. The muscles involved in this section were right rectus femoris (RF), right tibialis anterior (TA), right peroneus longus (PL), and left gastrocnemius lateral head (GLH). This section also consists of 3 main subsections thus are, the comparison of muscle behaviour among normal people, second is the comparison of muscle behaviour between normal people versus GA patient, and last is the muscle analysis of GA patient with assistive device versus without assistive device. All of the subsections contain 2 results representing 2 activities, walking and climbing stairs.

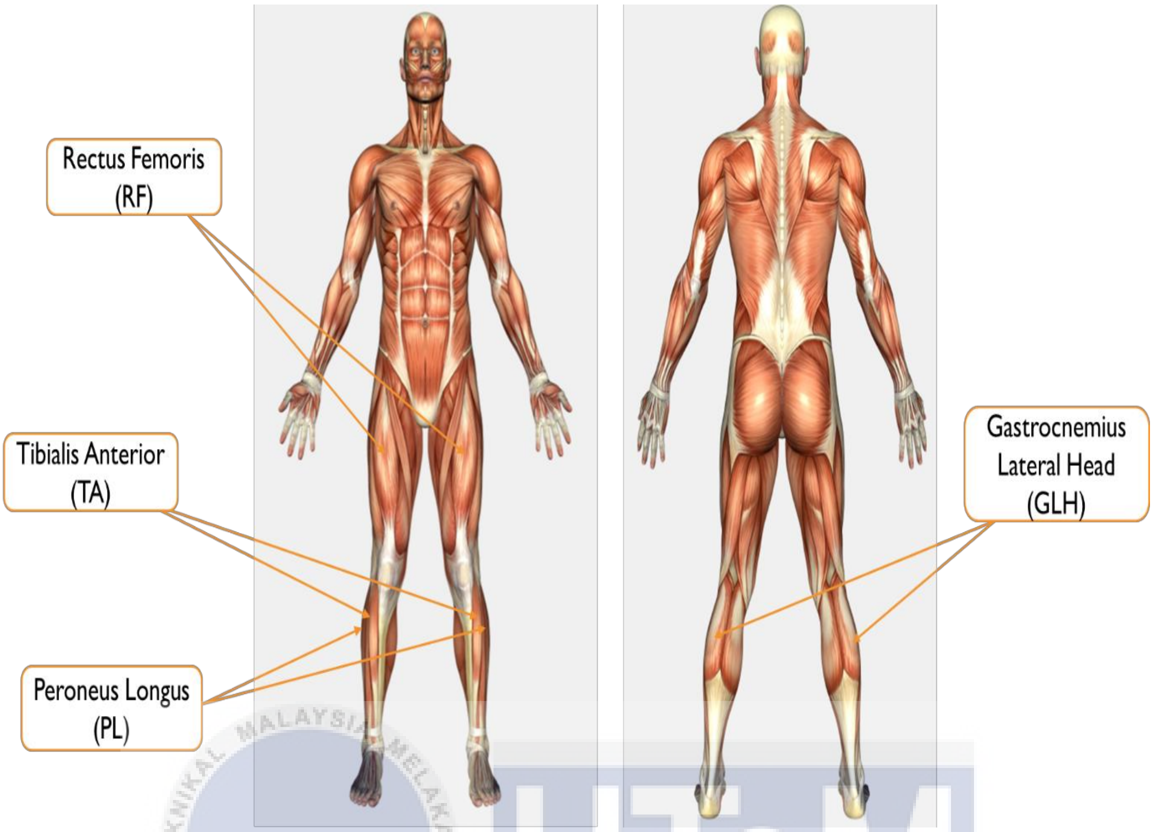

Figure 4.1 muscle selected to place Delsys sensor (EMG software manual)

Figure 4.1 above shows the muscle involved. The muscles above is being selected due to their function which the most crucial muscle in regards as the patient and respondent participating in the experiment as includes walking and climbing.

Table 4.1 The number of sensor on the muscle

Muscles	Function	EMG sensor number
Rectus Femoris (RF)	Flexes foot upward and inward, support arch of foot	EMG 12
Tibialis anterior (TA)	Flexes thigh at hip with other quadriceps muscles, extend knee	EMG 13
Peroneus Longus (PL)	Flexes foot downward, turns it outward	EMG 14
Gastrocnemius Lateral Head (GLH)	Flexes ankle and pulls up heel, flexes knee	EMG 15

Table 4.1 explains which muscle represent the EMG sensor. As soon as received the EMG tools and DELSYS Trigno Wireless EMG System, calibration and troubleshooting processes of each sensor need to be run in order to ensure the sensor in good condition and could functioning in well condition during the testing. After the first stage of calibration and troubleshooting process, a few sensors managed to be detected as malfunction. Thus, during the testing only the functioned involved being used to gain the data.

4.2 Muscle Activity Analysis On Normal People

4.2.1 Muscle activity analysis on normal people (walking) for RF

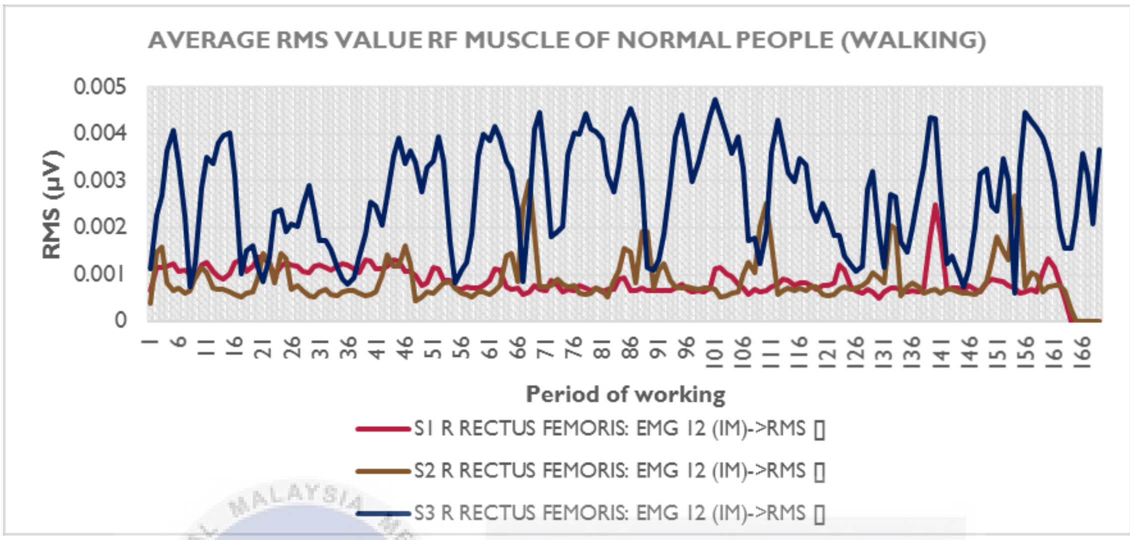

Figure 4.2.1: Graph of average RMS value RF muscle of NP

Figure 4.2.1 above shows the results from the experiment of 3 sample. All of the sample are in rest condition before the experiment commenced. This graph represents the average RMS (root mean square) value of rectus femoris (RF) during walking. Based on the graph it is clearly can be seen that sample 1 and sample 3 has almost similar pattern of muscle contraction. But not for sample 3. Sample 3 shows a different pattern which is the contraction is highest compared to the other two sample. The muscles usually started to contract while handing a work and must have a fatigue point at a certain period of the working day. There are two possibilities that may lead to this condition. First is sample 3 may in a fatigue condition from the beginning. Even though, the sample is let to rest 24 hours before the testing, the duration provide to the muscle may not enough for them to regain to its normal condition. Meanwhile, sample 1 and sample 2 able to regain their rest condition. To fix and restore a muscle takes anywhere from 24 to 48 hours. The decline in the RMS value of each subject indicated by the Figure 4.2.1 suggests that the contraction level increased as the working hours increased.

It shows that the rectus femoris muscles experienced fatigue during the prolonged contraction. The myoelectric manifestations observed for instances in the RMS of this muscles were mainly caused by the accumulation of metabolites within the muscles fibre to generate of inadequate motor and no global mechanism responsible for muscle fatigue (Enoka et al., 2008).

4.2.2 Muscle activity analysis on normal people (walking) for TA muscle

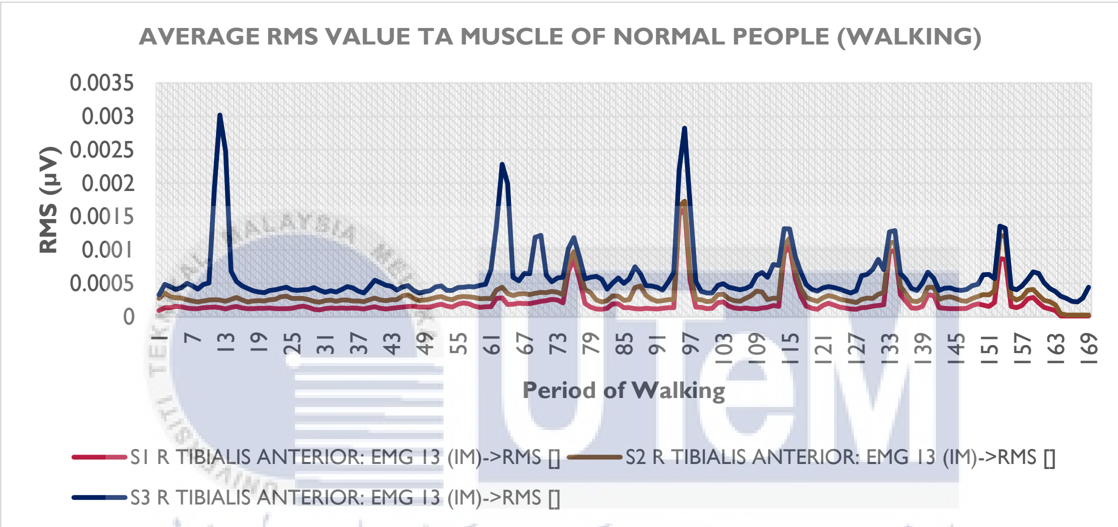

Figure 4.2.2: Graph of average RMS value TA muscle of NP

Based on Figure 4.22, the average RMS value of tibialis anterior (TA) muscle from EMG Delsys sensor 13, the 3 sample altogether produced an average amount of value during walking. All of them show the similar pattern of contraction amount. Even though for the previous muscle, rectus femoris (RF) sample 3 portrayed a different pattern but for this type of muscle the value of contraction among 3 sample is similar. It is the average of normal people to having that amount of muscle contraction during normal walking. The duration for the sample to each activity is 10 seconds. Within that time, the muscle are works as well as the steps taken by the sample. For normal people, 10 seconds is quite short time for them to face the muscle fatigue, but it is different case and condition when it comes to GA patient. Muscle strength of GA patient is weaker compared to normal people.

4.2.3 Muscle activity analysis on normal people (walking) for PL muscle

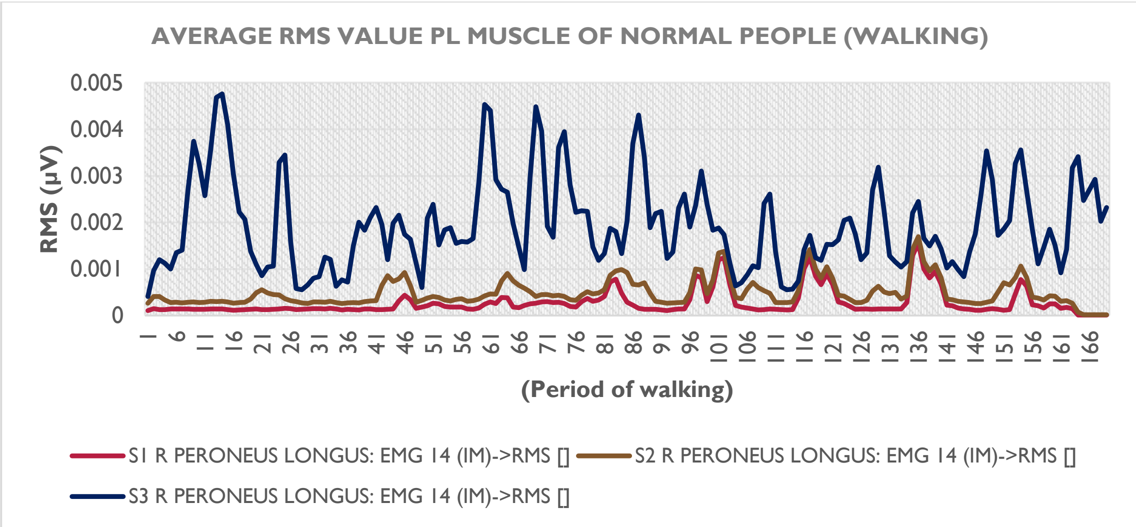

Figure 4.2.3: Graph of average RMS value PL muscle of NP

Figure 4.2.3 above shows the results from the experiment of 3 sample. All of the sample are in rest condition before the experiment commenced. This graph represents the average RMS (root mean square) value of peroneus longus (PL) during walking. Based on the graph it is clearly can be seen that sample 1 and sample 3 has almost similar pattern of muscle contraction. But not for sample 3. Sample 3 shows a different pattern which is the contraction is highest compared to the other two sample. The muscles usually started to contract while handing a work and must have a fatigue point at a certain period of the working day. There are two possibilities that may lead to this condition. First is sample 3 may in a fatigue condition from the beginning. Even though, the sample is let to rest 24 hours before the testing, the duration provide to the muscle may not enough for them to regain to its normal condition. Meanwhile, sample 1 and sample 2 able to regain their rest condition. This result of graph is almost similar with the graph 4.2.1 that has been discussed earlier.

4.2.4 Muscle activity analysis on normal people (walking) for GLH muscle

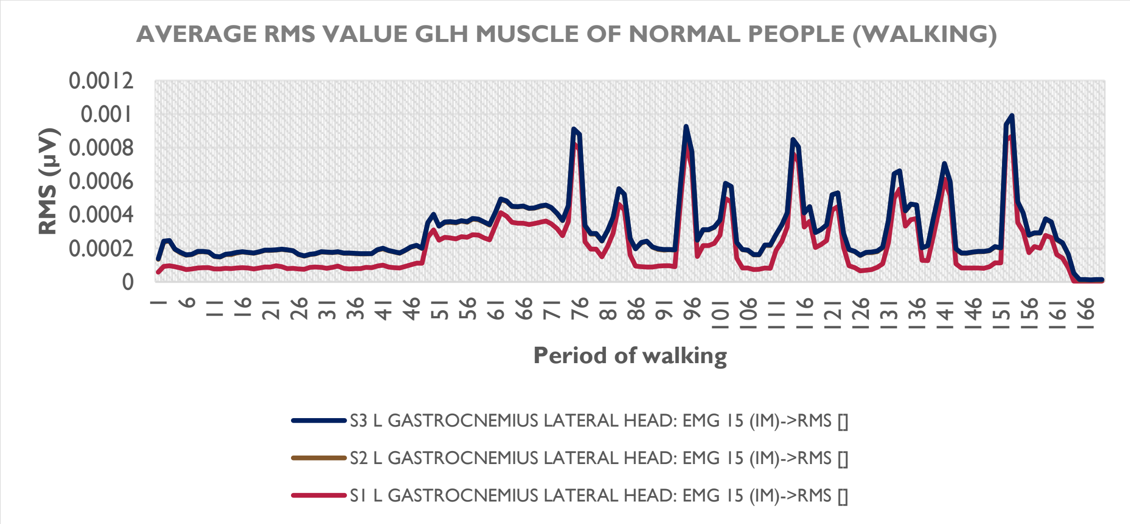

Figure 4.2.4: Graph of average RMS value GLH muscle of NP

Based on Figure 4.2.4, the average RMS value of gastrocnemius lateral head (GLH) muscle from EMG Delsys sensor 15, the 3 sample altogether produced an average amount of value during walking. All of them show the similar pattern of contraction amount. Even though for the previous muscle, rectus femoris (RF) and peroneus longus (PL) sample 3 portrayed a different pattern but for this type of muscle the value of contraction among 3 sample is similar. It is the average of normal people to having that amount of muscle contraction during normal walking. The duration for the sample to each activity is 10 seconds. Within that time, the muscle is working as well as the steps taken by the sample. From the graph it can be seen that the amount of muscle is increasing as the time taken for all 3 sample. The muscle amplitude starts to increase while conducting the works, it detected normally by using amplitude and frequency of the signal (Freitas, 2008). The literature Freitas (2008) shows that the amplitude of EMG signals increases in the time when the fatigue increases, otherwise the mean power frequency decreases. The RMS of the EMG signal was calculated using a moving window based on the equations in Chapter 3. The RMS is considered to accommodate the most signal insight on the amplitude of the EMG signal since it measures the power of a signal (Lewis, 2014)

4.3 Muscle Activity Analysis On Normal People (Climbing)

4.3.1 Muscle Activity Analysis On Normal People (Climbing) for RF Muscle

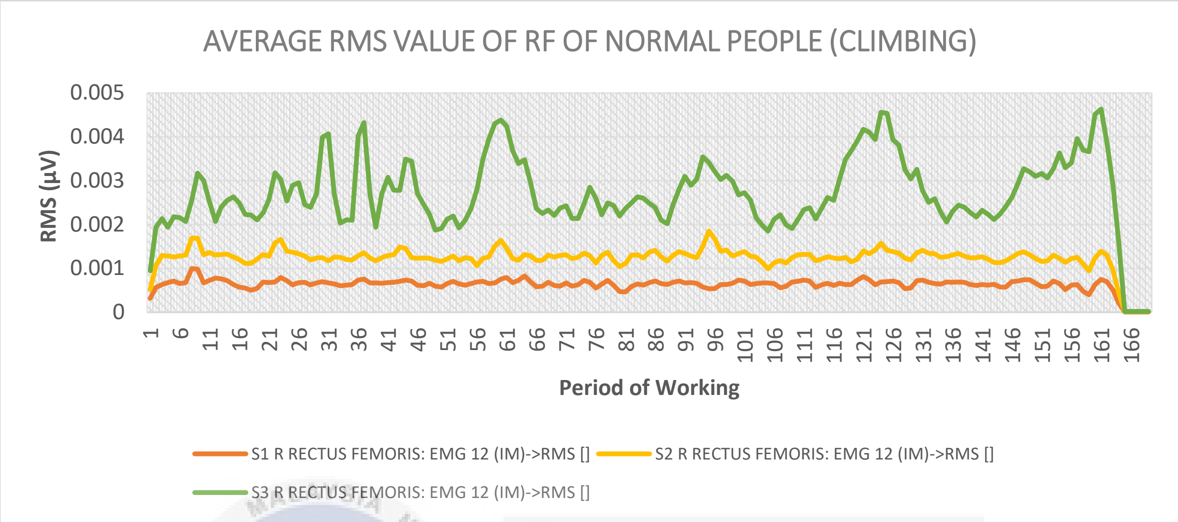

Figure 4.3.1: Graph of average RMS value RF muscle of NP

Figure 4.3.1 above shows the results from the experiment of 3 sample. All of the sample are in rest condition before the experiment commenced. This graph represents the average RMS (root mean square) value of rectus femoris (RF) during climbing stairs. Based on the graph it is clearly can be seen that sample 1 and sample 3 has almost similar pattern of muscle contraction. But not for sample 3. Sample 3 shows a different pattern which is the contraction is highest compared to the other two sample. The muscles usually started to contract while handing a work (walking) and must have a fatigue point at a certain period of the working day. There are two possibilities that may lead to this condition. First is sample 3 may in a fatigue condition from the beginning. Even though, the sample is let to rest 24 hours before the testing, the duration provide to the muscle may not enough for them to regain to its normal condition. Meanwhile, sample 1 and sample 2 able to regain their rest condition. To fix and restore a muscle takes anywhere from 24 to 48 hours.

4.3.2 Muscle Activity Analysis On Normal People (Climbing) for TA muscle

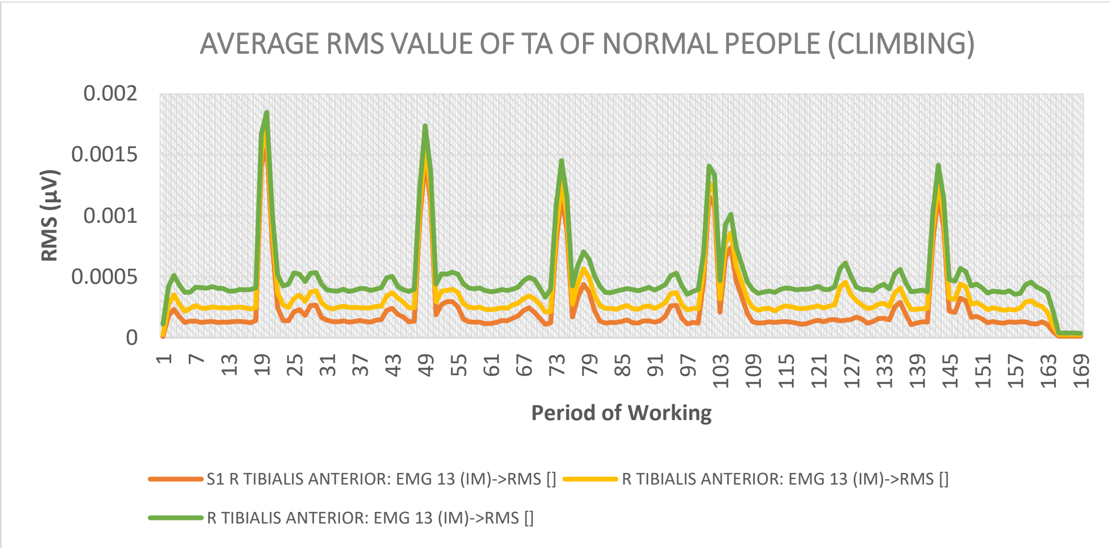

Figure 4.3.2: Graph of average RMS value TA muscle of NP

Based on Figure 4.3.2, the average RMS value of tibialis anterior (TA) muscle from EMG Delsys sensor 13, the 3 sample altogether produced an average amount of value during climbing stairs. All of them show the similar pattern of contraction amount. Even though for the previous muscle, rectus femoris (RF) and gastrocnemius lateral head (GLH) sample 3 portrayed a different pattern but for this type of muscle the value of contraction among 3 sample are alomost similar. It is the average of normal people to having that amount of muscle contraction during normal walking. The duration for the sample to each activity is 10 seconds. Within that time, the muscles are working as well as the steps taken by the sample. From the graph it can be seen that the amount of muscle is increasing as the time taken for all 3 sample. The muscle amplitude starts to increase while conducting the works, it detected normally by using amplitude and frequency of the signal (Freitas, 2008).

4.33 Muscle activity analysis on normal people (climbing) for PL muscle

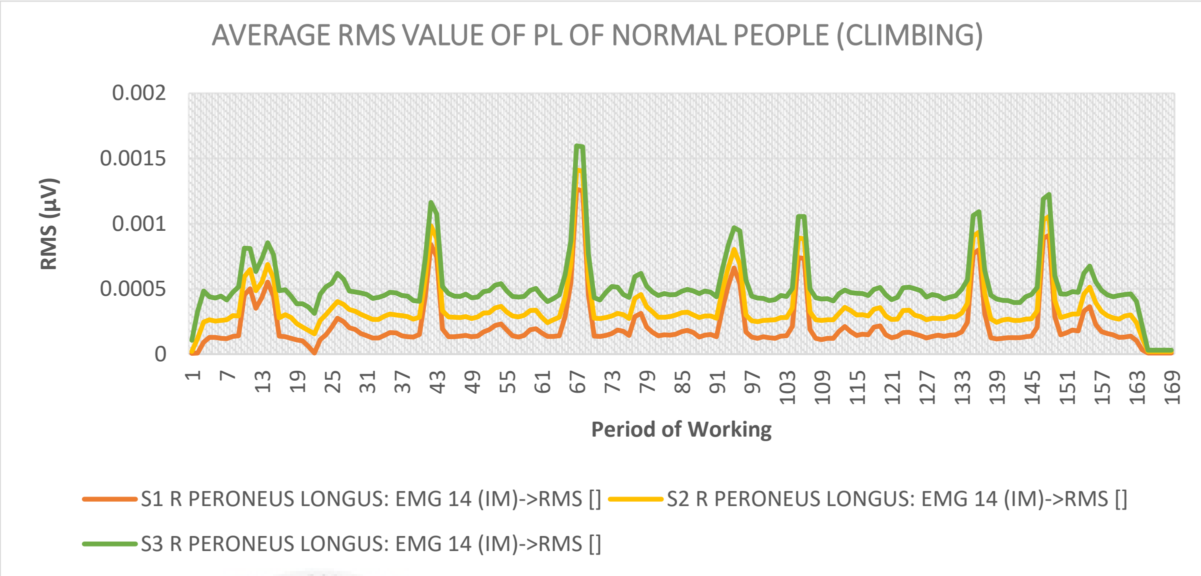

Figure 4.3.3: Graph of average RMS value PL muscle of NP

Based on Figure 4.3.3, the average RMS value of peroneus longus (PL) muscle from EMG Delsys sensor 14, the 3 sample altogether produced an average amount of value during climbing stairs. All of them show the similar pattern of contraction amount. Even though for the previous muscle, rectus femoris (RF) and gastrocnemius lateral head (GLH) sample 3 portrayed a different pattern but for this type of muscle the value of contraction among 3 sample are almost similar. Sample 1 representing by the orange line showing the lowest contraction compared to the other two sample. Meanwhile, the green line which representing by sample 3 shows the highest contraction. But for this muscle the result is not far different from each sample. The data is collected by the EMG software by using the Delsys EMG sensor wireless.

4.3.4 Muscle activity analysis on normal people (climbing) for GLH muscle

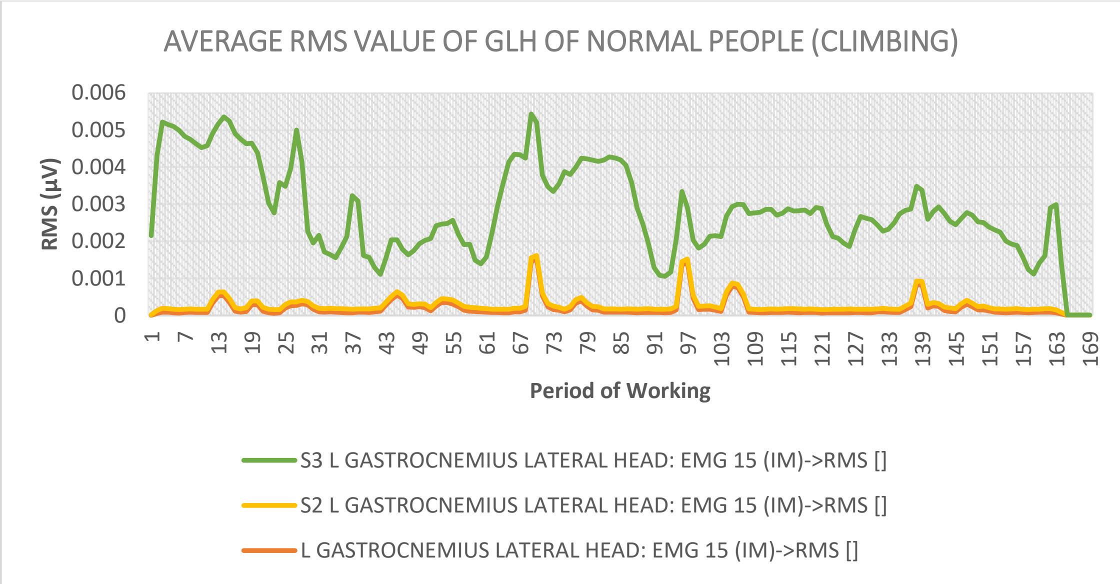

Figure 4.3.4: Graph of average RMS value GLH muscle of NP

Figure 4.3.4 above shows the results from the experiment of 3 sample. All of the sample are in rest condition before the experiment commenced. This graph represents the average RMS (root mean square) value of gastrocnemius lateral head (GLH) during climbing stairs. Based on the graph it is clearly can be seen that sample 1 and sample 3 has almost similar pattern of muscle contraction. But not for sample 3. Sample 3 shows a different pattern which is the contraction is highest compared to the other two sample. The muscles usually started to contract while handing a work (walking) and must have a fatigue point at a certain period of the working day. There are two possibilities that may lead to this condition. First is sample 3 may in a fatigue condition from the beginning. Even though, the sample is let to rest 24 hours before the testing, the duration provide to the muscle may not enough for them to regain to its normal condition. Meanwhile, sample 1 and sample 2 able to regain their rest condition. To fix and restore a muscle takes anywhere from 24 to 48 hours. Therefore, state of condition of sample can influence the muscle activity of the subjects while conducting works but it depends on lifestyle, working posture, endurance and load distribution towards human body. However, from this output the increasing the muscle contraction the shorter time-to-fatigue taken by the muscle. Second possibilities that may lead to this condition is the external noise that may affect the reading of data.

4.4 Muscle Activity Analysis On Normal People Vs GA Patient (Walking)

4.4.1 Muscle activity analysis on normal people vs GA patient (walking) for RF muscle

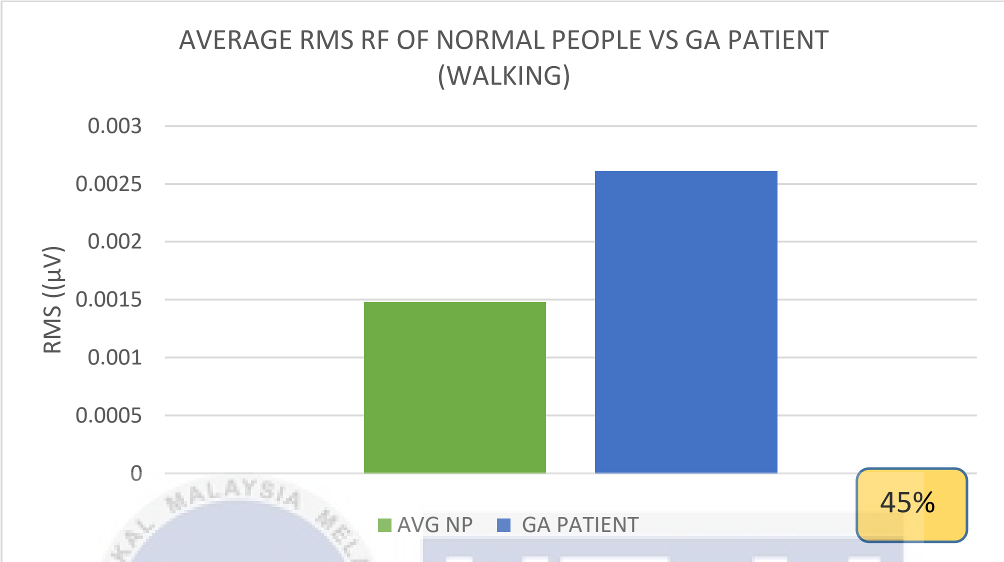

Figure 4.4.1: Graph of comparison RMS value between NP and GA patient

Figure 4.4.1 shows the comparison of average RMS (µV) value between normal people versus Gait Abnormalities (GA) patient during walking. It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Green bar representing the average RMS of normal people meanwhile the blue bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For rectus femoris (RF) muscle, RMS value of normal people is 45% smaller compared to GA patient. That means GA patient has a higher muscle contraction than normal people. The formula to calculate the percentage has been mentioned in chapter 3. This result is expected as GA patient's muscle have this kind of muscle condition, more sensitive and easier to fatigue compared to normal people's muscle. The main function of the assistive device is to reduce the muscle contraction to make it closer to the normal people.

4.4.2 Muscle Activity Analysis On Normal People Vs GA Patient (Walking) for TA Muscle

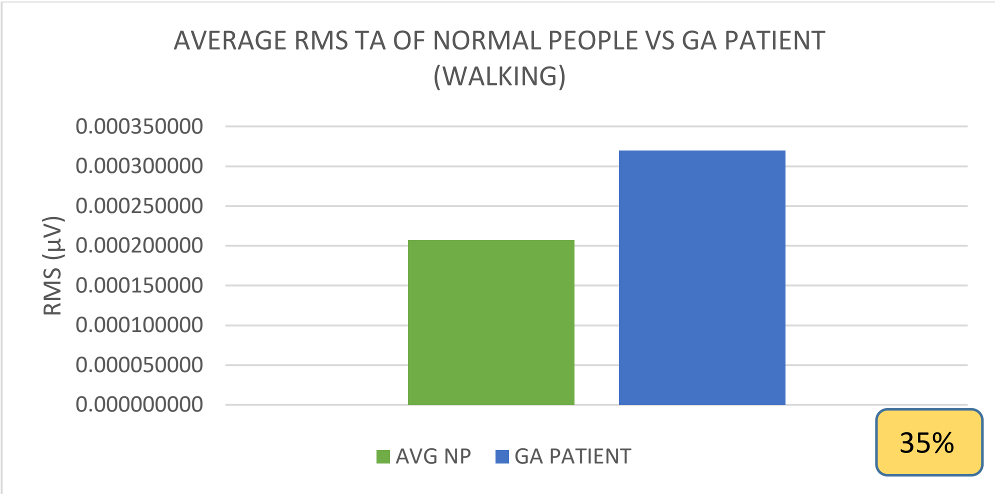

Figure 4.4.2: Graph of comparison RMS value between NP and GA patient

Figure 4.42 shows the comparison of average RMS (µV) value between normal people versus Gait Abnormalities (GA) patient during walking for the second muscle, tibialis anterior (TA). It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Green bar representing the average RMS of normal people meanwhile the blue bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For tibialis anterior (TA) muscle, RMS value of normal people is 35% smaller compared to GA patient. That means GA patient has a higher muscle contraction than normal people. The formula to calculate the percentage has been mentioned in chapter 3. This result is expected as GA patient's muscle have this kind of muscle condition, more sensitive and easier to fatigue compared to normal people's muscle. The main function of the assistive device is to reduce the muscle contraction to make it closer to the normal people.

4.4.3 Muscle activity analysis on normal people vs GA patient (walking) for PL muscle

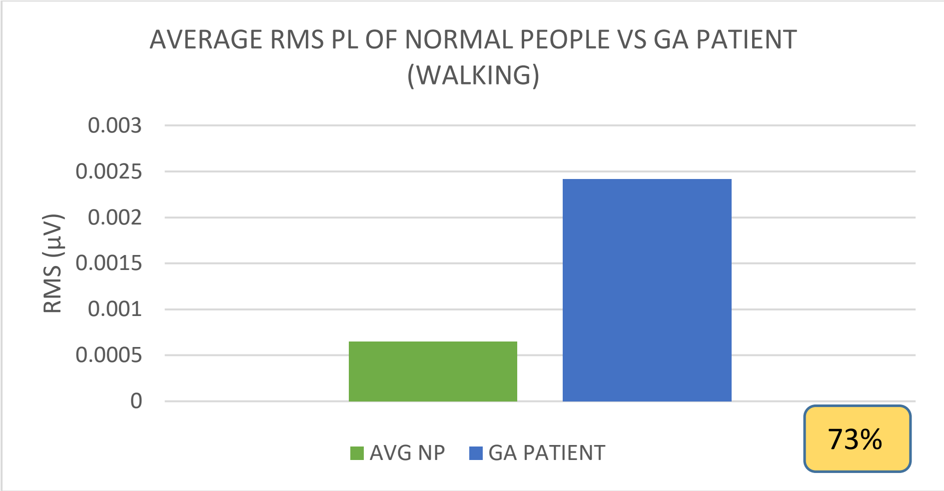

Figure 4.4.3: Graph of comparison RMS value between NP and GA patient

Figure 4.43 shows the comparison of average RMS (µV) value between normal people versus Gait Abnormalities (GA) patient during walking for the third muscle, peroneus longus (PL). It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Green bar representing the average RMS of normal people meanwhile the blue bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For peroneus longus (PL) muscle, RMS value of normal people is 73% smaller compared to GA patient. That means GA patient has a higher muscle contraction than normal people. 73% is quite big difference value. This value resulting time-to-fatigue of the muscle smaller for GA patient compared to normal people. The formula to calculate the percentage has been mentioned in chapter 3. This result is expected as GA patient's muscle have this kind of muscle condition, more sensitive and easier to fatigue compared to normal people's muscle. The main function of the assistive device is to reduce the muscle contraction to make it closer to the normal people.

4.4.4 Muscle activity analysis on normal people vs GA patient (walking) for GLH muscle

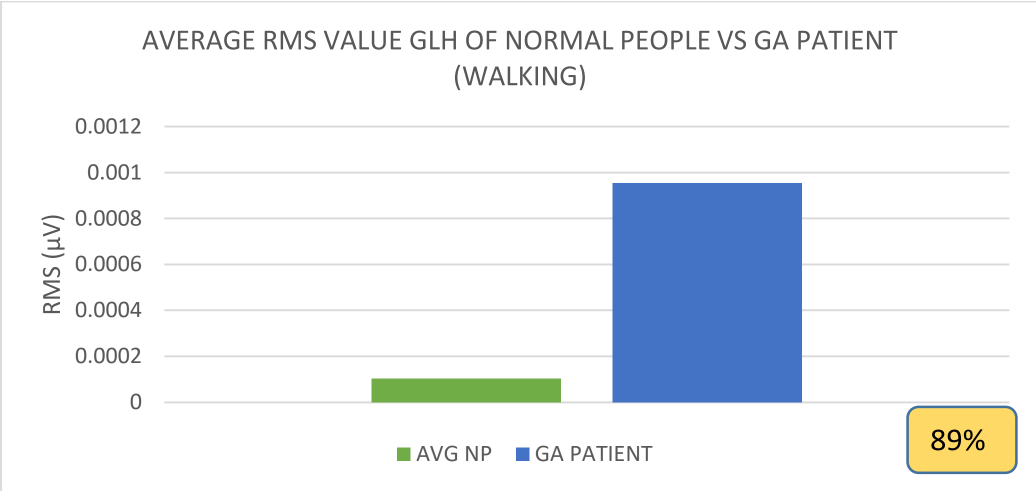

Figure 4.4.4: Graph of comparison RMS value between NP and GA patient

Figure 4.4.4 shows the comparison of average RMS (µV) value between normal people versus Gait Abnormalities (GA) patient during walking for the fourth muscle, gastrocnemius lateral head (GLH). It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Green bar representing the average RMS of normal people meanwhile the blue bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For gastrocnemius lateral head (GLH) muscle, RMS value of normal people is 89% smaller compared to GA patient. That means GA patient has a higher muscle contraction than normal people. To be compared, among the four muscles, this gastrocnemius lateral head (GLH) muscle has the biggest difference of RMS value between normal people and GA patient.

4.5 Muscle Activity Analysis On Normal People Vs GA Patient (Climbing)

4.5.1 Muscle activity analysis on normal people vs GA patient (climbing) for RF muscle

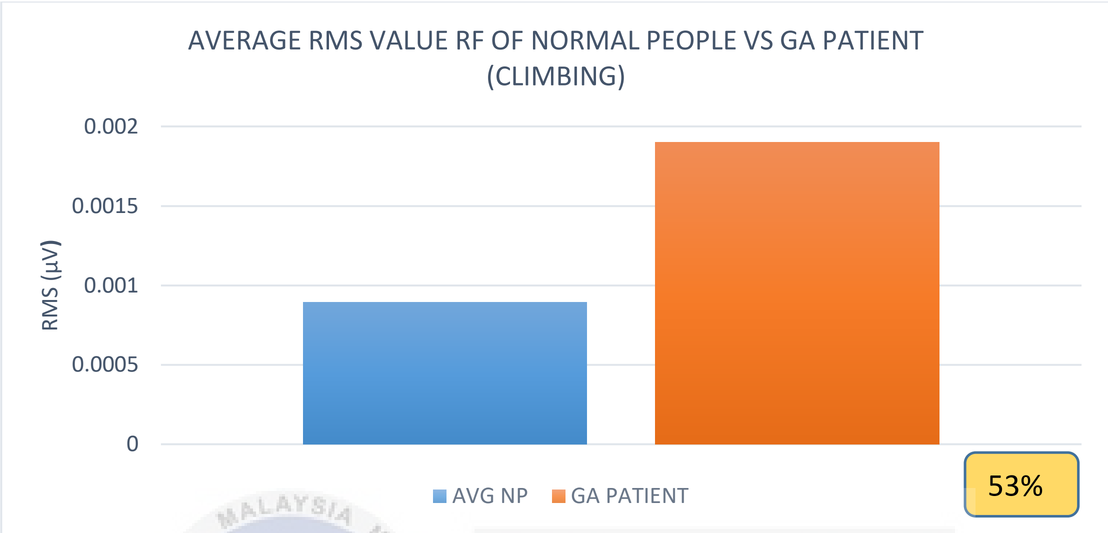

Figure 4.5.1: Graph of comparison RMS value between NP and GA patient

Figure 4.5.1 shows the comparison of average RMS (µV) value between normal people versus Gait Abnormalities (GA) patient during climbing stairs. It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Blue bar representing the average RMS of normal people meanwhile the orange bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For rectus femoris (RF) muscle, average RMS value of GA patient is 53% higher compared to normal people. That means normal people has a smaller muscle contraction than GA patient. Normal people take longer time-to-fatigue compared to GA patient. GA patient's muscle weaker than normal people.

4.5.2 Muscle Activity Analysis On Normal People Vs GA Patient (Climbing) for TA Muscle

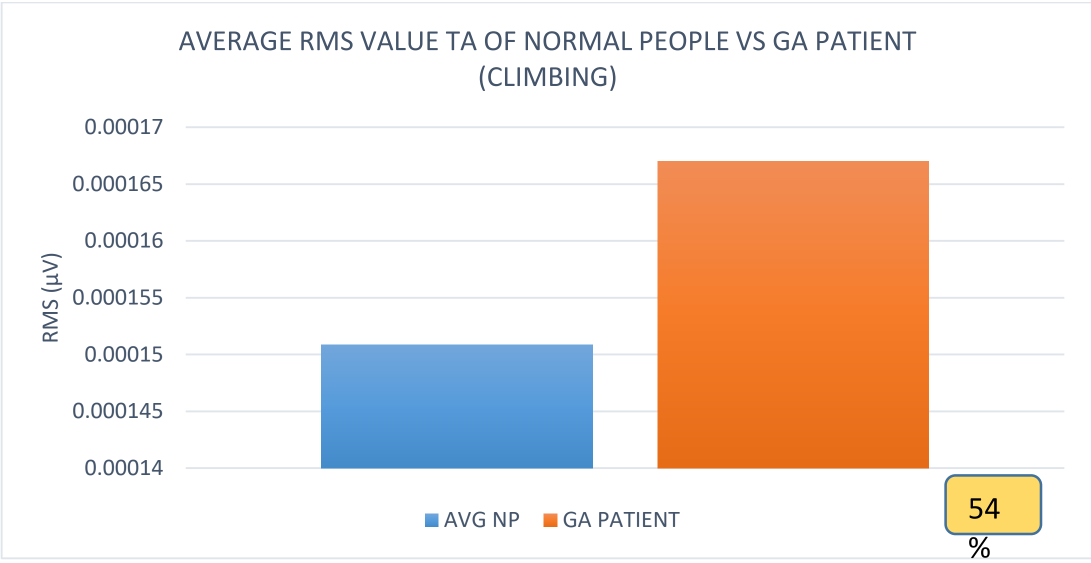

Figure 4.5.2: Graph of comparison RMS value between NP and GA patient

Figure 4.5.2 shows the comparison of average RMS (µV) value between normal people versus Gait Abnormalities (GA) patient during climbing stairs for the second muscle, tibialis anterior (TA). It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Blue bar representing the average RMS of normal people meanwhile the orange bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For tibialis anterior (TA) muscle, average RMS value of GA patient is 54% higher compared to normal people. That means normal people has a smaller muscle contraction than GA patient. Normal people take longer time-to-fatigue compared to GA patient. GA patient's muscle weaker than normal people. The formula to calculate the percentage has been mentioned in chapter 3

4.5.3 Muscle Activity Analysis On Normal People Vs GA Patient (Climbing) for PL Muscle

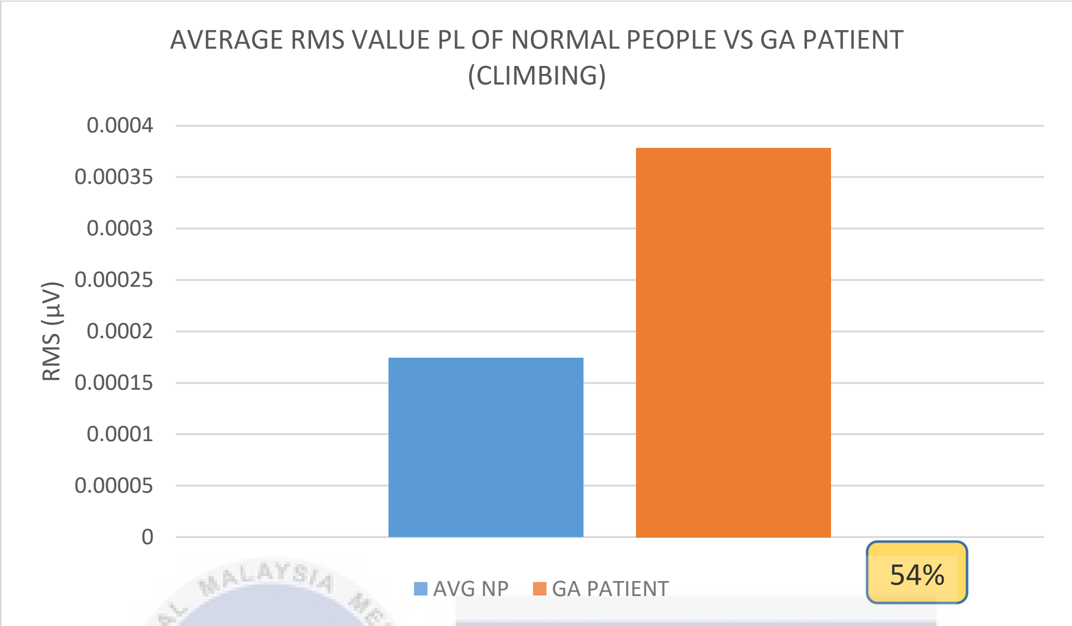

Figure 4.5.3: Graph of comparison RMS value between NP and GA patient

Figure 4.5.3 shows the comparison of average RMS (µV) value between normal people versus Gait Abnormalities (GA) patient during climbing stairs for the third muscle, peroneus longus (PL). It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Blue bar representing the average RMS of normal people meanwhile the orange bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For peroneus longus (PL) muscle, average RMS value of GA patient is 54% higher compared to normal people. That means normal people has a smaller muscle contraction than GA patient. Normal people take longer time-to-fatigue compared to GA patient. GA patient's muscle weaker than normal people. This value resulting time-to-fatigue of the muscle smaller for GA patient compared to normal people.

4.5.4 Muscle Activity Analysis On Normal People Vs GA Patient (Climbing) for GLH Muscle

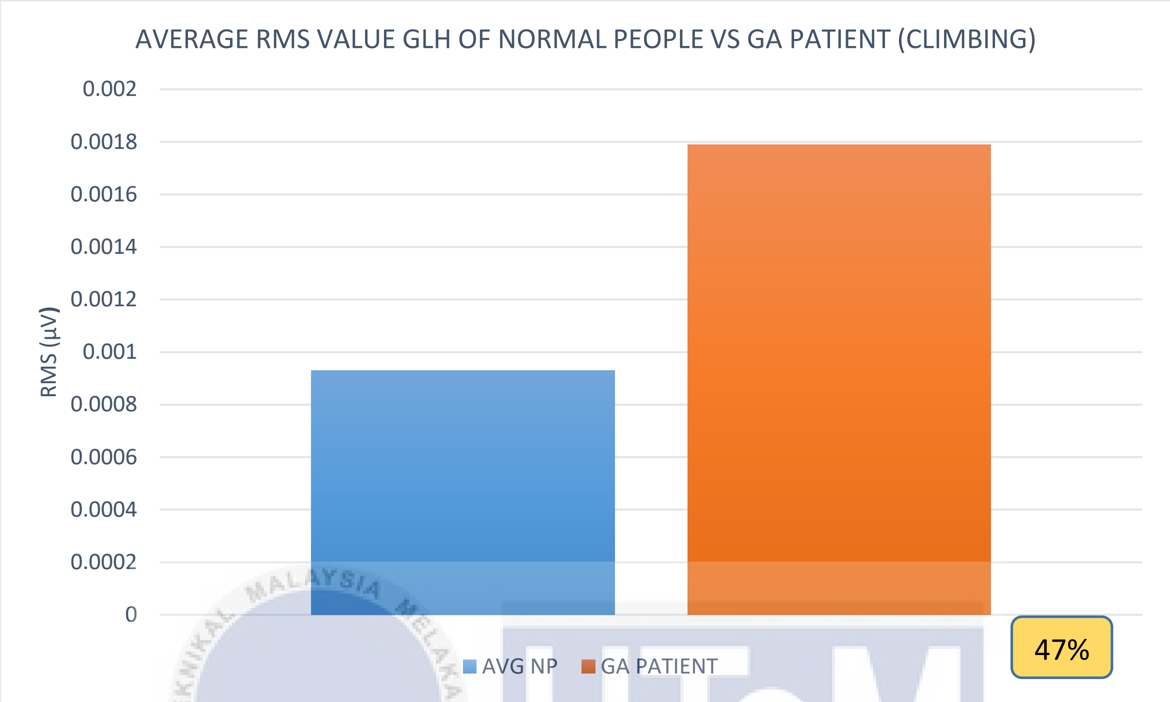

Figure 4.5.4: Graph of comparison RMS value between NP and GA patient

Figure 4.5.4 shows the comparison of average RMS (μV) value between normal people versus Gait Abnormalities (GA) patient during climbing stairs for the fourth muscle, gastrocnemius lateral head (GLH). It explains the difference of average RMS value among normal people versus GA people. The average from previous 3 sample of normal people, sample 1, sample 2 and sample 3 is being calculated. Thus, the average of RMS value of normal people is being compared with the data gained from GA patient. Blue bar representing the average RMS of normal people meanwhile the green bar representing the RMS value of GA patient. The RMS value is basically the value of muscle contractions produced during the activity (walking). For gastrocnemius lateral head (GLH) muscle, average RMS value of GA patient is 47% higher compared to normal people. That means normal people has a smaller muscle contraction than GA patient. Normal people take longer time-to-fatigue compared to GA patient. GA patient's muscle weaker than normal people.

4.6 Muscle activity comparison on GA patient with device vs without device (Walking).

4.6.1 Muscle activity comparison on GA patient with device vs without device (Walking) for RF muscle.

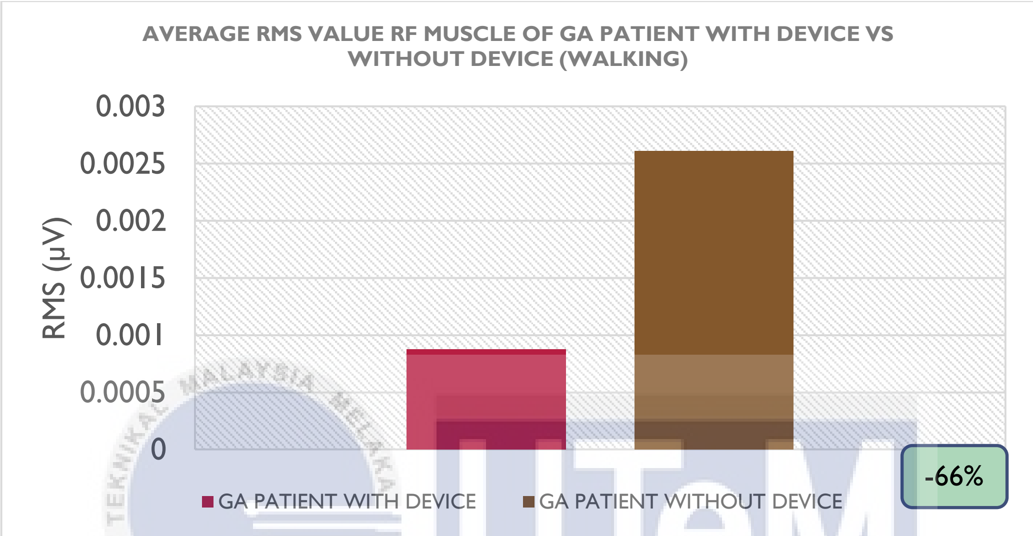

Figure 4.6.1: Graph of comparison RMS value of GA patient with and without device

Figure 4.6.1 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during walking activity. Based on the Figure above, pink bar is representing the GA patient with device, meanwhile the brown bar is representing the result of GA patient without device. This graph is the result for the rectus femoris (RF) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 66%. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue.

4.6.2 Muscle activity comparison on GA patient with device vs without device (Walking) for GA muscle

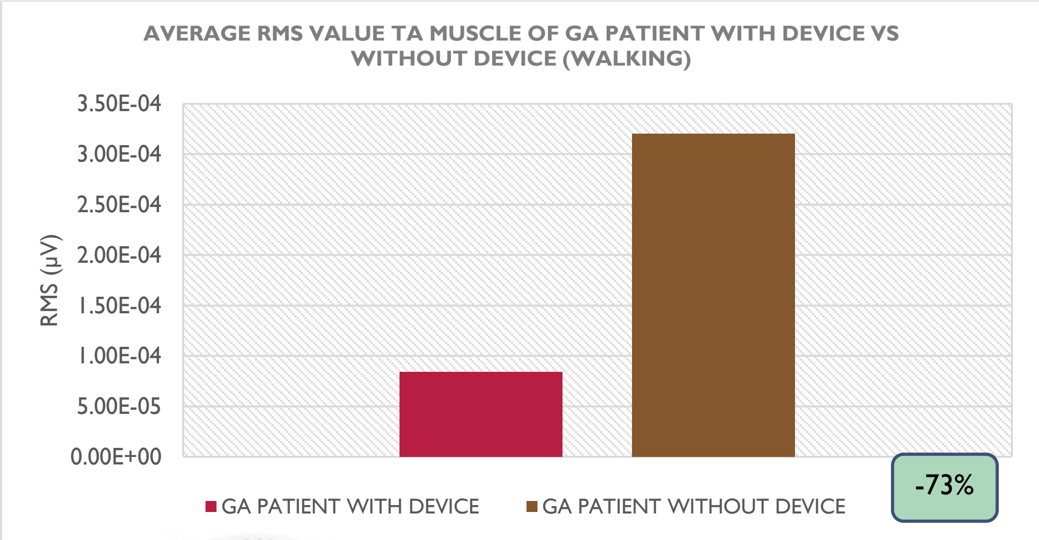

Figure 4.6.2: Graph of comparison RMS value of GA patient with and without device

Figure 4.62 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during walking activity. Based on the Figure above, pink bar is representing the GA patient with device, meanwhile the brown bar is representing the result of GA patient without device. This graph is the result for the tibialis anterior (TA) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 73 %. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue.

4.6.3 Muscle activity comparison on GA patient with device vs without device (Walking) for PL muscle

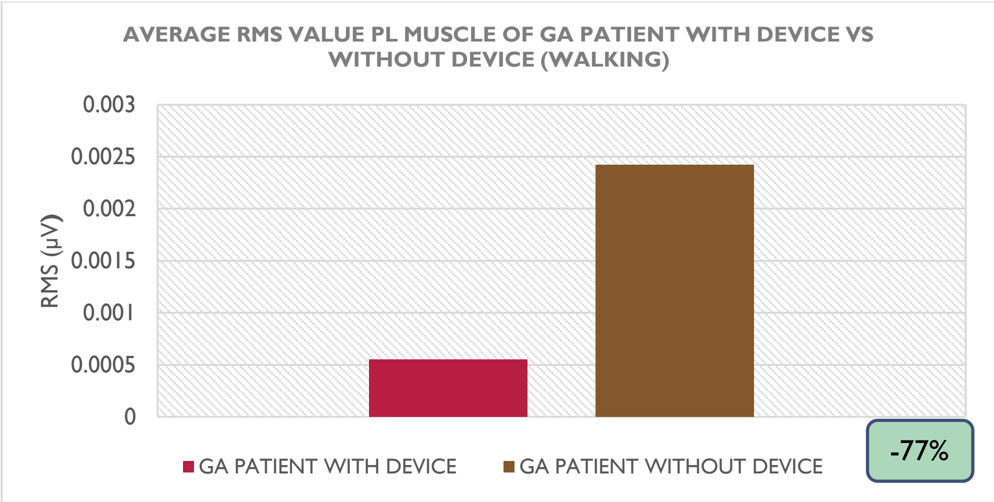

Figure 4.6.3: Graph of comparison RMS value of GA patient with and without device

Figure 4.6.3 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during walking activity. Based on the Figure above, pink bar is representing the GA patient with device, meanwhile the brown bar is representing the result of GA patient without device. This graph is the result for the rectus peroneus longus (PL) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 77%. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue.

4.6.4 Muscle activity comparison on GA patient with device vs without device (Walking) for GLH muscle

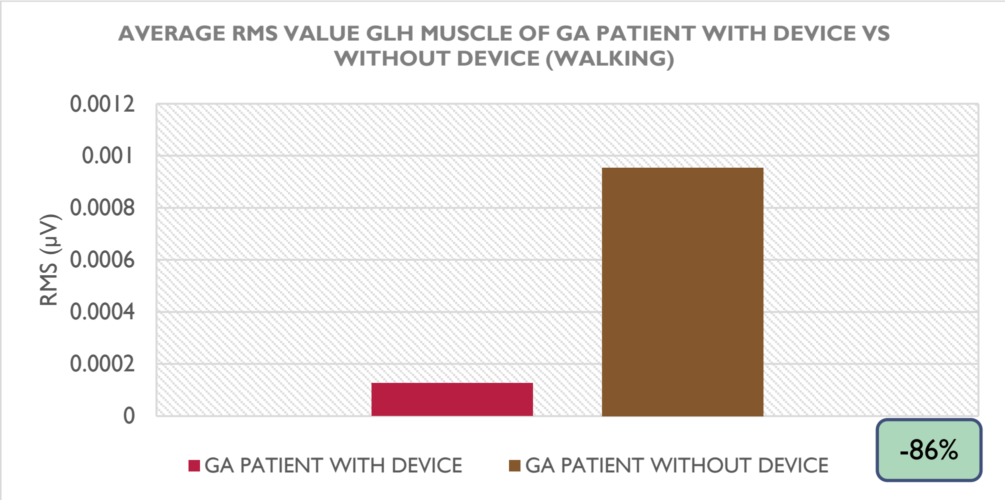

Figure 4.6.4: Graph of comparison RMS value of GA patient with and without device

Figure 4.64 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during walking activity. Based on the Figure above, pink bar is representing the GA patient with device, meanwhile the brown bar is representing the result of GA patient without device. This graph is the result for the gastrocnemius lateral head (GLH) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 86%. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue.

4.7 Muscle Activity Comparison On GA Patient with Device Vs Without Device (Climbing)

4.7.1 Muscle activity comparison on GA patient with device vs without device (Climbing) for RF Muscle

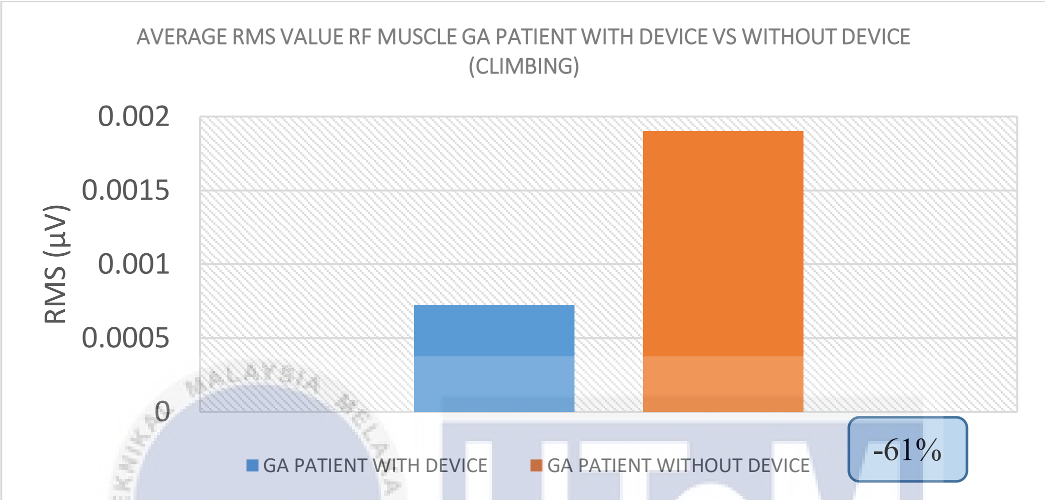

Figure 4.7.1: Graph of comparison RMS value of GA patient with and without device

Figure 4.71 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during climbing stairs activity. Based on the Figure above, pink bar is representing the GA patient with device, meanwhile the brown bar is representing the result of GA patient without device. This graph is the result for the rectus femoris (RF) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 61%. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue.

4.7.2 Muscle activity comparison on GA patient with device vs without device (Climbing) for GA Muscle

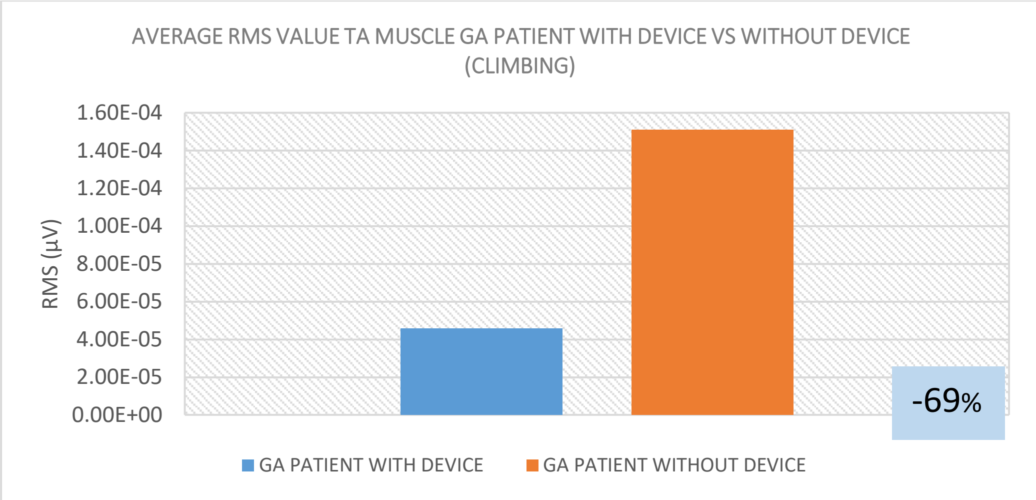

Figure 4.7.2: Graph of comparison RMS value of GA patient with and without device

Figure 4.72 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during climbing stairs activity. Based on the Figure above, pink bar is representing the GA patient with device, meanwhile the brown bar is representing the result of GA patient without device. This graph is the result for the tibialis anterior (TA) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 69%. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue.

4.7.3 Muscle activity comparison on GA patient with device vs without device (Climbing) for PL Muscle

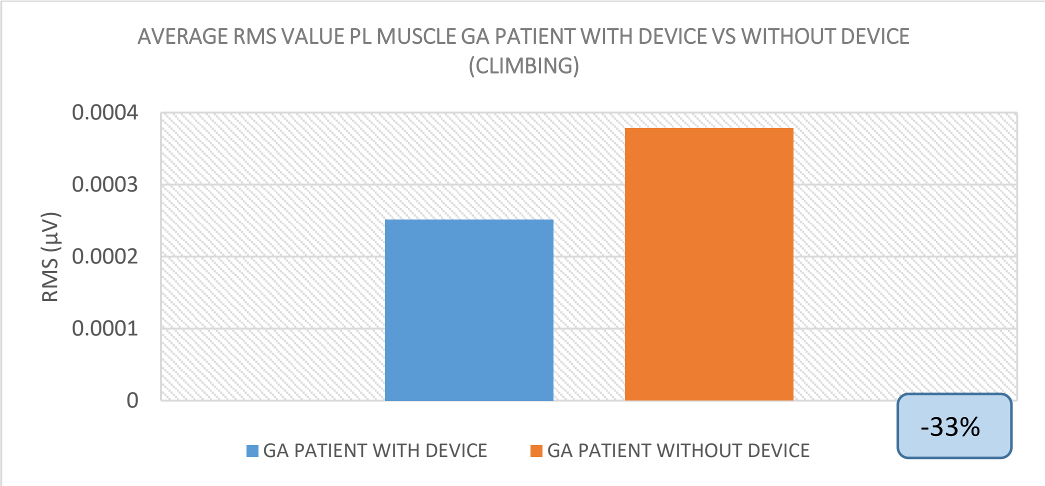

Figure 4.7.3: Graph of comparison RMS value of GA patient with and without device

Figure 4.73 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during climbing stairs activity. Based on the Figure above, pink bar is representing the GA patient with device, meanwhile the brown bar is representing the result of GA patient without device. This graph is the result for the peroneus longus (PL) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 33%. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue. To be compared from the other muscles, this muscle has the smallest amount of RMS percentage value of reduction.

4.7.4 Muscle activity comparison on GA patient with device vs without device (Climbing) for GLH Muscle

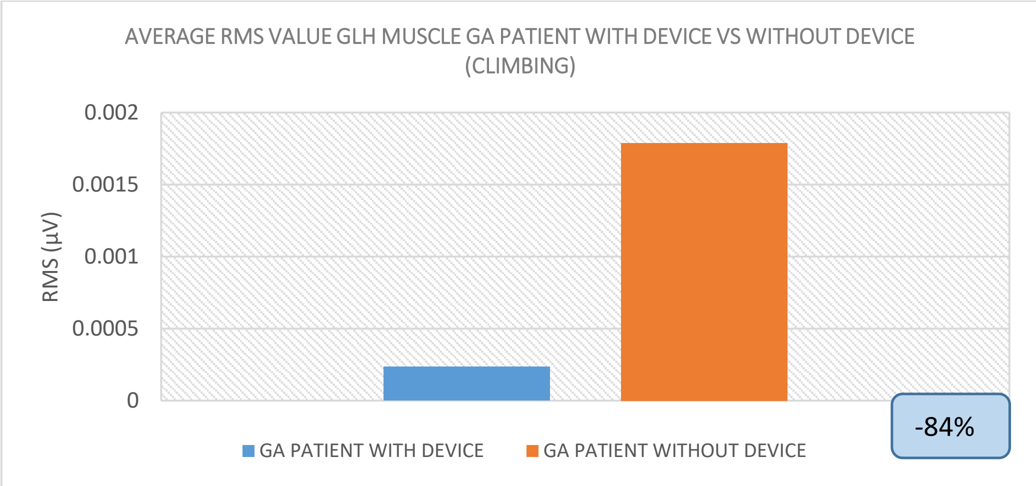

Figure 4.7.4: Graph of comparison RMS value of GA patient with and without device

Figure 4.7.4 shows the comparison of average RMS (µV) value of GA patient with device versus without the assistive device during climbing stairs activity. Based on the Figure above, blue bar is representing the GA patient with device, meanwhile the orange bar is representing the result of GA patient without device. This graph is the result for the gastrocnemius lateral head (GLH) muscle. From this graph, the reduction of percentage in RMS value with the assistive device has reduced by 84%. The amount of muscle contraction reduces when the GA patient with the device compared without the device. When the muscles contraction reduces, time-to-fatigue of muscles will increase as the muscle contraction is inversely proportional to time-to-fatigue. The highest reduction of percentage RMS value goes to thus muscle compared to 3 previous muscle.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter basically discusses about the summary of this project. Besides that, the recommendation and the future work of this project also included in this chapter. The chapter comprises all the present conclusion which on achieving the project objectives, the sustainability views on the project and provide suggestion and recommendation for other researcher to continue the study of the project.

5.1 Conclusion

Based on the title of the project, the main reason of this project is to assist Gait abnormalities patient in order to overcome the gait disorders. Patient with this abnormality are facing complications to deal with their daily activities. The previous study shows that GA patient tend to lose their strength and ability to walk normally when their muscle begins to tired due to continuous stretch and load at their leg muscle. During this situation, patient unable to proceed with their daily activities. This study is expected to able to solve this problem by enable to reduce their uncomfortableness thus reducing their muscle stress and contraction. This will be proven by analysing the muscle behaviour of the patient with the Gait Abnormality Assistive Device (GUARD) by using the sEMG.

As in return, this device may able to assist them in daily activities and promote themselves to be independent. The problem statement in this project is the current existing design of counter balance arm in the market is difficult to be own and the assistive device also are not provided in PRC centres due to the cost of the assistive device is too high and the product manufactured are not localized and only available in the market overseas. New assistive device has been fabricated but there is no data and evidence yet to proving the effectiveness of the device. Hence, due to the problems a method to validate the result of the device is being approached by using the sEMG (surface electromyography). This project consists of three objectives that have been achieved throughout the study of the project.

To begin with, the first objectives which is to identify the patients affected muscles involved, muscle strength and their range of motion in order to investigate the muscle activity and gait analysis of normal people and GA people. This objective has been achieved by constructing interview session that could gather the information regarding the history and background of the patients, types of muscles involved, and the patients muscles strength and range of motion. During interview, all the respondents' muscles strength and their range of motion is justified and validated by the therapist in PRC centre.

Next objective is to analyse the muscle activity and gait analysis of the assistive device GUARD for GA people. This means that the study is conducted to collect the data and information on how the device could react on the GA patient. Does the device will help the patient's muscle in reducing the contraction as well as increasing the time-to-fatigue. The experiment was being conducted on the GA patient for a few types of muscles. The muscles were being selected based on the criteria which is all of them are amongst of the most active muscles walking and climbing stairs movement. They are rectus femoris (RF), tibialis anterior (TA), perenous longus (PL) and last one is gastrocnemius lateral head (GLH).

Finally, the final steps of this research which is to evaluate the effectiveness of the assistive device to muscle and time-to-fatigue of GA people. This last objective was successfully achieved by the data obtained and the calculation that has being made in the previous chapter 3 and chapter 4. The reduction percentage value of muscle contractions has made this project able to gain the most important required data. Overall, the muscle has shown a positive result which the amount of muscle contraction reduced significantly with the device compared without the device on GA patients. Time-to-fatigue increased as well as the muscle contraction reduced. GA patient's muscle able to achieve longer duration before the muscle begin to fatigue. They manage to utilize the leg to do the daily chores longer than usually they did. That is the most crucial part as it is one of the largest objective for this project which to ease the patient and let them live more independently.

In conclusion, this final year project is done successfully. All objectives are achieved and the problem statements is solved where an economical and ergonomic method to evaluate the effectiveness of the assistive device in order to fulfil the patient's requirement was successfully conducted. Not only that, the device may be useful for other gait abnormalities post treatment such as stroke, hemiparesis and any other abnormalities but it requires further study and research to be discovered.

5.2 Recommendation and Future Work

In this project, for the recommendation and future works of the study is stated in this section is to help for further improvement of the study. There are few recommendations that is commented by the therapist and patients in PRC centre in Melaka. The recommendations are:

- This research project and the resulting thesis with all publication that related have made a small contribution to the general but more understanding of GA gait abnormalities issues, psychophysical and biomechanical factors, development of lumbar support and anthropometric advantage to society, though essential to everyone's life, are taken for granted.

- Although there have been published work by other researchers in the general area of muscle activity test, method and mathematical modelling, most publications have addressed each other issues. These publications are scattered far and wide and the circumstance in that scope of studies was done. The previous study regarding this research generally and limited, while the scope of the study was narrowed and focuses on a specific area. Besides, the majority of previous research was performed in the simulation study and test.

- The author believes that the development of psychophysical and biomechanical factors analysis for GA works issues in Malaysian industries using the validation method in proving the functionality of lumbar support device is a new contribution to the social knowledge. Other than that, the journey in the development of lumbar support can also be a guide to the designer in using the data and improving the design based on this method.

There are many factors which can influence the GA abnormalities issues in this world such as genetic, accidents, environment, workplace, facilities, ergonomic and others to be studied in future using the same methodology. There is an opportunity for the industrial area, safety and healthy society, and organisation to be a concern in depth. A comprehensive study could be done by involving a variety of sector, different gender, and working environment to compare the different result of the study. Besides, the duration of the experiment can be longer and specific to compare the improvement of lumbar support with the existing result.

Furthermore, the development of the assistive device can be improvising in term of the design and functionality. Design is one of the main crucial part in fabricating an assistive device especially for medical purposes. Currently, there are so many Gait Abnormalities problem existed in our society. Thus, this kind of device will be a helpful to many people out there. A good design may produce a better result in term of performance and value.

Lastly, the recommendations for future works is investigating the condition where the noise resulting from surrounding can be reduce during EMG data acquisition. Based on the result discussed in chapter 4, there might be some error during the data collection due to the presence of external noise. That is why for further improvement, make sure the condition of the surrounding is clear and try to avoid any additional noise that may disturb the data collection during the experiment conducted.

5.3 Sustainability

In this project, the importance to develop sustainable product that provide environmental, economic and social benefits is concerned throughout the study of the project. For the environmental aspects, the Polylactide or PLA is used as the material of the assistive device. Basically, the PLA material is made from the plant based resource which made the material of the product is biodegradable and recyclable. Other than that, in the product only three types of material are being used because the fewer types of material will minimize waste management for the environment. Apart from that, the types of assistive device is consider as passive device because to operate the product, no electrical power is required. Hence, without using any energy source, the uses of the product will save the usage of electrical energy. To conclude, the developed assistive device considers as eco-friendly product which helps to protect the environment and conserve the energy and material resources.

5.4 Complexity

Throughout the study of the project, the complexity of the project is to fulfil the standard operational procedure to obtained anthropometry measurement databased that involved disability people as participant for the project. The measurer must have skill in the area of anthropometric measurement. Furthermore, to obtained the measurement of disabled people needs patience and skills as their limitation of body movement. Besides obtaining the anthropometry data, the next complexity of the project is to interact with any people due this current pandemic Covid-19 situation. Amount of sample had to reduce as PERKESO Rehabilitation centre restricted any outsiders to do any experiment to their patients. Next, the complexity that related to this project is to know the behaviour of the muscles fatigue during the EMG data acquisition where the subject need to always keep maintaining the pace so that the noise resulting from surrounding would be reduce. The understanding of analysing EMG data is a little bit complicated due to the different activity conducted in different situation between with device and without device.

5.5 Long Life Learning

In this project, this work that had been performed and completed includes lifelong learning contains the ability in problem solving and helps the disabled society. Throughout the study of this project, when gathering data collection, which required human to human interaction, we need to learn and have the ability in communication skills, interaction and collaboration skills as this work collaborated with one of PERKESO rehabilitation centre in the country. From this project as well, the work has further aim to patent and commercialize the product of counter balance arm slings.

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APPENDIX A

GANTT CHART

No	ACTIVITY	PLAN START	PLAN PERIOD	WEEK 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Briefing of PSM1 with coordinator	1	1	■																											
2	Briefing with supervisor	2	1		■																										
3	Brainstorming for ideas & title decision	2	1		■																										
4	Study & research on topic chosen	3	4			■	■	■	■																						
5	Plan project's structure	4	8				■	■	■	■	■	■	■	■																	
6	Research Methodology	5	3					■	■	■																					
7	Obtain Preliminary Result	7	3							■	■	■																			
8	Proposal Report Writing	9	2									■	■																		
9	Presentation	11	1											■																	
10	Report Submission	12	1											■																	
11	Seminar for PSM2	13	1												■																
12	Planning	5	9									■	■	■	■	■															
13	Report Progression	14	1														■														
14	Meeting with supervisor	2	26		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
15	Muscle Testing using EMG	18	5																		■	■	■	■	■						
16	Result & Discussion	21	5																					■	■	■	■	■			
17	Report Writing	24	4																								■	■	■	■	
18	Presentation	28	1																												■
19	Report Submission	28	1																												■

B- ASSISTIVE DEVICE FOR GA PATIENT

C- GA PATIENT

D- DELSYS WIRELESS EMG SENSOR ON GA PATIENT'S LEG

E- EMG SOFTWARE

F- RAW DATA FROM EXTRACT FROM EMG SOFTWARE

X []	S1 L GASTROCNEMIUS LATERAL HEAD: EMG 15 (IM)->RMS []	S2 L GASTROCNEMIUS LATERAL HEAD: EMG 15 (IM)->RMS []	S3 L GASTROCNEMIUS LATERAL HEAD: EMG 15 (IM)->RMS []
0	5.83668E-05	7.63074E-05	4.06484E-06
0.0621	9.24948E-05	0.000145934	4.2325E-06
0.1242	9.69873E-05	0.000149168	1.70548E-06
0.1863	9.03671E-05	0.000103441	2.05461E-06
0.2484	8.28513E-05	9.0903E-05	2.21372E-06
0.3105	7.33042E-05	8.57977E-05	2.11593E-06
0.3726	7.67495E-05	8.62798E-05	2.37308E-06
0.4347	8.39337E-05	9.5254E-05	2.60362E-06
0.4968	8.58231E-05	9.42526E-05	2.32582E-06
0.5589	8.57712E-05	9.16494E-05	1.83315E-06
0.621	7.76761E-05	7.498E-05	1.75886E-06
0.6831	7.80731E-05	6.98799E-05	2.13801E-06
0.7452	8.21363E-05	8.10182E-05	2.93136E-06
0.8073	7.88191E-05	8.55592E-05	4.0207E-06
0.8694	8.33711E-05	8.9624E-05	3.56656E-06
0.9315	8.52299E-05	9.27871E-05	1.8429E-06
0.9936	8.31106E-05	9.11874E-05	1.56158E-06
1.0557	7.8471E-05	9.28821E-05	1.58741E-06
1.1178	8.38097E-05	9.52021E-05	1.51518E-06
1.1799	8.89401E-05	9.96174E-05	1.49482E-06
1.242	8.82029E-05	0.000100632	1.52435E-06
1.3041	9.60652E-05	9.3953E-05	1.57208E-06
1.3662	9.08864E-05	0.000103973	1.56556E-06
1.4283	7.88919E-05	0.000110839	1.58203E-06
1.4904	8.18612E-05	0.000103565	1.57061E-06
1.5525	7.83383E-05	8.55252E-05	1.50028E-06
1.6146	7.53775E-05	7.88167E-05	1.53793E-06
1.6767	8.66921E-05	7.64326E-05	1.60244E-06
1.7388	8.9663E-05	7.70987E-05	1.78315E-06
1.8009	8.80794E-05	9.09352E-05	1.84805E-06
1.863	8.22292E-05	9.41261E-05	1.844E-06
1.9251	8.63168E-05	8.83517E-05	1.8183E-06
1.9872	9.39854E-05	8.43217E-05	1.82894E-06
2.0493	8.14995E-05	8.96168E-05	1.77484E-06
2.1114	7.7727E-05	9.38188E-05	1.61793E-06
2.1735	7.89218E-05	9.04758E-05	1.72789E-06
2.2356	7.93531E-05	8.78426E-05	2.08075E-06
2.2977	8.79605E-05	8.00857E-05	1.99444E-06
2.3598	8.60761E-05	8.21572E-05	1.60576E-06
2.4219	9.50564E-05	9.58643E-05	1.85762E-06
2.484	0.000100373	9.81341E-05	2.23423E-06
2.5461	8.83309E-05	9.7777E-05	2.14434E-06
2.6082	8.4873E-05	9.47079E-05	1.71004E-06

2.6703	8.40913E-05	8.77329E-05	1.64076E-06
2.7324	9.34881E-05	9.4339E-05	2.03115E-06
2.7945	0.000102807	0.000104783	2.07688E-06
2.8566	0.00011221	0.000104134	1.69999E-06
2.9187	0.000112465	8.7744E-05	1.57543E-06
2.9808	0.000265873	8.56825E-05	1.63061E-06
3.0429	0.00031019	9.11782E-05	1.65342E-06
3.105	0.000248262	8.3922E-05	1.61343E-06
3.1671	0.000267197	8.75612E-05	2.13252E-06
3.2292	0.000262843	9.36233E-05	2.46552E-06
3.2913	0.00025709	9.45681E-05	3.29962E-06
3.3534	0.000270207	9.2734E-05	3.29968E-06
3.4155	0.000266714	8.99067E-05	2.84362E-06
3.4776	0.000282031	9.27852E-05	2.99619E-06
3.5397	0.000279289	9.2514E-05	2.30043E-06
3.6018	0.000262496	9.35012E-05	2.34863E-06
3.6639	0.000252024	8.71898E-05	2.89505E-06
3.726	0.000335169	7.5147E-05	4.02037E-06
3.7881	0.000412333	7.95688E-05	3.73968E-06
3.8502	0.000392437	8.80578E-05	2.16037E-06
3.9123	0.000355246	9.41373E-05	1.99262E-06
3.9744	0.000349525	9.77896E-05	1.68622E-06
4.0365	0.000350139	0.000100934	1.5837E-06
4.0986	0.000342554	9.52525E-05	1.72122E-06
4.1607	0.000348215	9.2175E-05	2.12792E-06
4.2228	0.000356618	9.32724E-05	2.71684E-06
4.2849	0.000363043	9.32873E-05	2.7324E-06
4.347	0.000347243	9.44199E-05	2.23825E-06
4.4091	0.000316949	9.06215E-05	2.24578E-06
4.4712	0.000275196	9.02598E-05	2.47434E-06
4.5333	0.000359313	9.32869E-05	2.11441E-06
4.5954	0.000823925	8.71619E-05	1.70007E-06
4.6575	0.00078961	8.82118E-05	1.92556E-06
4.7196	0.000240324	9.36546E-05	3.28041E-06
4.7817	0.00019513	9.08349E-05	3.42999E-06
4.8438	0.000194971	9.1076E-05	2.26802E-06
4.9059	0.000150836	9.34193E-05	1.9224E-06
4.968	0.000212416	9.307E-05	2.07392E-06
5.0301	0.000291353	9.27244E-05	2.01061E-06
5.0922	0.000462053	9.30631E-05	1.67442E-06
5.1543	0.000429813	9.22673E-05	1.72091E-06
5.2164	0.000162025	9.68922E-05	1.73573E-06
5.2785	9.41427E-05	0.00010274	1.78754E-06
5.3406	9.10345E-05	0.000141583	2.76045E-06
5.4027	8.91115E-05	0.000151626	2.8663E-06
5.4648	9.00765E-05	0.000116739	3.00462E-06
5.5269	9.57834E-05	9.8898E-05	3.42611E-06

5.589	9.76719E-05	9.33165E-05	2.59266E-06
5.6511	9.57976E-05	9.5974E-05	1.8022E-06
5.7132	9.17687E-05	9.85457E-05	1.79486E-06
5.7753	0.000491733	9.39278E-05	4.08339E-06
5.8374	0.000830195	9.37525E-05	4.19944E-06
5.8995	0.000680223	9.49744E-05	2.15628E-06
5.9616	0.000152883	9.46892E-05	2.43527E-06
6.0237	0.000216229	9.36992E-05	2.40579E-06
6.0858	0.000216647	9.2581E-05	1.9616E-06
6.1479	0.000230957	9.38724E-05	1.77599E-06
6.21	0.000279373	8.76302E-05	1.61355E-06
6.2721	0.000497628	8.76613E-05	2.14116E-06
6.3342	0.00047753	9.02314E-05	2.19145E-06
6.3963	0.000142628	9.09281E-05	1.67868E-06
6.4584	8.30503E-05	0.000108598	1.57203E-06
6.5205	8.41031E-05	0.000104786	1.55394E-06
6.5826	7.45827E-05	8.65982E-05	1.57518E-06
6.6447	7.50026E-05	8.59457E-05	1.57965E-06
6.7068	8.33864E-05	0.000135951	1.66429E-06
6.7689	8.24307E-05	0.00013524	2.21494E-06
6.831	0.00018851	9.29035E-05	2.2014E-06
6.8931	0.000240702	9.75742E-05	1.64545E-06
6.9552	0.0003267	8.51472E-05	1.56609E-06
7.0173	0.000764658	8.38109E-05	1.57605E-06
7.0794	0.000716461	8.73257E-05	1.53265E-06
7.1415	0.000327003	8.32228E-05	1.52081E-06
7.2036	0.000361075	8.74644E-05	1.52467E-06
7.2657	0.000204753	8.92122E-05	1.50833E-06
7.3278	0.000222484	8.88731E-05	1.53232E-06
7.3899	0.000246472	9.26834E-05	1.56321E-06
7.452	0.000427401	9.16747E-05	1.56025E-06
7.5141	0.000448914	8.15605E-05	1.58863E-06
7.5762	0.000205978	8.14793E-05	1.57236E-06
7.6383	9.61389E-05	9.61865E-05	1.51641E-06
7.7004	8.55941E-05	9.55638E-05	1.53903E-06
7.7625	6.65718E-05	9.09675E-05	1.57999E-06
7.8246	6.99714E-05	0.000104555	1.55805E-06
7.8867	7.40261E-05	0.000101333	3.84127E-06
7.9488	8.80842E-05	9.17108E-05	4.03417E-06
8.0109	0.00010732	9.70049E-05	2.03307E-06
8.073	0.000233568	0.000131676	1.66372E-06
8.1351	0.000499344	0.000143686	1.63656E-06
8.1972	0.000554485	0.000106204	1.60084E-06
8.2593	0.00033237	9.02136E-05	1.5496E-06
8.3214	0.000372066	9.14147E-05	1.55984E-06
8.3835	0.000378063	7.99857E-05	1.55283E-06
8.4456	0.000129936	7.26051E-05	1.53574E-06
8.5077	0.000127512	8.69878E-05	1.66183E-06

8.5698	0.000270592	0.000101507	2.11135E-06
8.6319	0.000429519	9.78128E-05	2.09583E-06
8.694	0.00061314	9.1276E-05	1.69797E-06
8.7561	0.000513846	8.25437E-05	1.84185E-06
8.8182	0.00010741	8.72118E-05	2.21365E-06
8.8803	8.42487E-05	8.65057E-05	2.41945E-06
8.9424	8.43477E-05	8.65222E-05	2.10451E-06
9.0045	8.36675E-05	9.34643E-05	1.63481E-06
9.0666	8.2988E-05	9.71343E-05	1.62511E-06
9.1287	8.20683E-05	9.83107E-05	1.78065E-06
9.1908	9.06288E-05	9.63818E-05	1.99789E-06
9.2529	0.000113922	9.49023E-05	2.00727E-06
9.315	0.000113195	8.82082E-05	1.77297E-06
9.3771	0.000846581	9.15018E-05	1.60686E-06
9.4392	0.000867654	0.000122158	1.5571E-06
9.5013	0.000353387	0.000123649	1.5587E-06
9.5634	0.00030012	0.000110276	1.57062E-06
9.6255	0.000174806	0.000102663	1.6005E-06
9.6876	0.000210117	8.06606E-05	1.62444E-06
9.7497	0.000201298	9.06289E-05	1.56506E-06
9.8118	0.000278564	9.59073E-05	1.85425E-06
9.8739	0.000264997	9.07967E-05	2.13862E-06
9.936	0.000162508	8.94406E-05	2.02152E-06
9.9981	0.000142639	8.82979E-05	2.61837E-06
10.0602	8.61678E-05	7.69608E-05	2.94554E-06
10.1223	5.77963E-06	4.43974E-05	2.31235E-06
10.1844	5.77963E-06	6.0668E-06	2.01982E-06
10.2465	5.77963E-06	6.0668E-06	2.03997E-06
10.3086	5.77963E-06	6.0668E-06	1.84405E-06
10.3707	5.77963E-06	6.0668E-06	3.25666E-06
10.4328	5.65259E-06	5.93344E-06	3.40829E-06
AVG	0.000213857	9.15864E-05	2.09174E-06