UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF KNEE BRACES FOR OSTEOARTHRITIS PATIENT

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

by

MUHAMAD HUSNI BIN HUSSEIN
B071110369
890131-01-5577

FACULTY OF ENGINEERING TECHNOLOGY
2015

DECLARATION

I hereby, declared this report entitled “DEVELOPMENT OF KNEE BRACES FOR OSTEOARTHRITIS PATIENT” is the results of my own research except as cited in the references.

Signature :
Author’s Name : MUHAMAD HUSNI BIN HUSSEIN
Date :

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory committee is as follows:

(Signature of Supervisor)

……

APPROVAL

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(Signature of Principal Supervisor)

……

ABSTRAK

Dalam tesis ini, untuk mereka bentuk semula mekanisme dan membuat penambahbaik peranti pemulihan bagi kelemahan lutut berfungsi dibentangkan. Tujuan mereka bentuk semula ini adalah untuk membantu lutut pesakit lemah berfungsi dalam proses pemulihan. Kajian literatur digunakan untuk mengenal pasti dan penyelesaian masalah pada reka bentuk yang sedia ada dan untuk mengumpul data spesifikasi peranti pemulihan yang sedia ada sebelum process pembangunan konsep reka bentuk dilaksanakan. Konsep mereka bentuk peranti pemulihan yang telah dibangunkan berdasarkan criteria reka bentuk produk. Reka bentuk akhir akan dipilih dengan menggunakan kaedah yang sesuai iaitu kaedah saringan dan pemarkahan. Dengan menggunakan perisian Solidwork, model reka bentuk akhir telah berjaya dibangunkan dan digunakan untuk menganalisis komponen kritikal pada peranti. Keputusan daripada analisis bahagian kritikal menunjukkan bahawa reka bentuk yang dicadangkan boleh digunakan dengan selamat.

ABSTRACT

There is a need, to redesign and improve the mechanism and functional of rehabilitation device for knee functional weakness. The purpose is to help the knee functional weakness, patient in the process of rehabilitation. Literature study used to identify the problems and solutions of the existing design and to collect specification data and patent of an existing device before the development process of conceptual design is implemented. The conceptual designs have been developed based on product design criteria. The final design has been selected by using suitable methods which are screening and scoring methods. By using software Solidwork, the model of the final design has been successfully developed and used to analyze the critical component of the device. Result from the analysis of critical part indicates that the proposed design is possible to use safely.

DEDICATION

I would first like to express heartfelt thanks for the warmth of love to my adored Parents:

Mr. Hussein Bin Daing Diduk

Mrs. Siti Asnah Binti Hj Daeng Matata

And for my respected Brother and Sister:

Siti Norhidayah Binti Hussein

Mohd Taufiq Bin Hussein

Muhammad Hanif Bin Hussein

Haziq Aiman Bin Hussein

Thanks you for the endless support and loves to me..

May God bless those who have been giving me their support to excellence further in my future undertakings.

ACKNOWLEDGEMENT

First of all, I would like to thank to my supervisor, Engr Hassan Bin Attan for giving me a lot of knowledge and a lot of information during this final year project period. Without his support and encouragement I can't afford to complete this final year project

I also would like to thank all of my lecturers in Universiti Teknikal Malaysia Melaka (UTeM) who have helped me from the beginning until the end of this final year project period. Without their support and advice I can never complete this technical report with success.

Special thanks to my fellow friend, for helping me most in getting the information and detail about everything that related to this final project. They give full commitment in helping me finding the solution to my problem and solve it together. Not to be forget to all my family members because they had given a lot of support and attention to me in doing and finishing with success on this final year project. I really appreciated for what you guys have done for me.

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THANK YOU SO MUCH

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Most of the patients that are concerned about the function of knee braces already have a ligament injury. The patients are usually concerned about the functioning of knee braces because it can help them using the knee braces in proper ways. The functional knee braces are designed to compensate for a torn knee ligament. The functional knee braces is not as effective as the normal knee ligaments, but it can help patients who have the ligament injury.

There is a lot of studies that involve studying about the effectiveness of the knee braces. The summary of the knee braces can be concluded as the functional knee braces provide some protections to the knee at low loads. This means, the study proves that when force is applied to a knee that is supported by the functional knee brace, it is more stable than without using the brace. This project is purposely to make the design improvement for the functional knee braces. The existing knee braces that are commonly used nowadays are heavier in weight. Plus, the cost of knee braces is also higher in price. At the end of this project, the result expectations are to redesign the knee braces that are lower in cost.

1.2 Problem Statement

a) The rehabilitation for knees injury is commonly by using the knee braces. There are a lot of knees braces types in the market. The knee braces is used to support the knees after the injury happens. The existing product is not so reliable to use and costly. The biggest issue with existing design is, the strap is normally open by its own and the knee braces will slip. It can cause the person to feel not comfortable when they walk.

1.3 Objective

The objective for the improved design of the knee braces are:

a) To redesign a device that support and help knee movement
b) To make an improvement to the existing product
c) To analyze and simulate the functional movement of devices

1.4 Scope of Project

To make sure that the project goes smoothly, the scopes of the project are being identified as follows:

a) To redesign knee braces using Reverse Engineering and Cad Tool
b) To make an improvement to the knee braces and eliminate the difficulty that people face when using the existing knee braces.
c) The device simulates using Cad Tool

1.5 Outline of report

This report will be segmented into four chapters. The first chapter is the introduction of the report. It generally discusses about the background of study, problem statement, scope, objectives as well as the limitation of the study, importance of study, and research methodology. On chapter two is the literature review, which will be done based on journals, books, internet resources and previous studies done on the related topics. As for chapter three, the methodology to construct the research will be explained. All relevant data collection method as well as the analysis will be recorded. Lastly, the details and information on the knee braces will be included in chapter 4, the case study chapter.

1.6 Result expectation

At the end of this project, the result expectation are identified and expectation of this study helps to redesign a better knee braces than the existing product in the market. The result also will show the improvement of the knee braces and the comparison between the improvement of the knee braces and existing product.

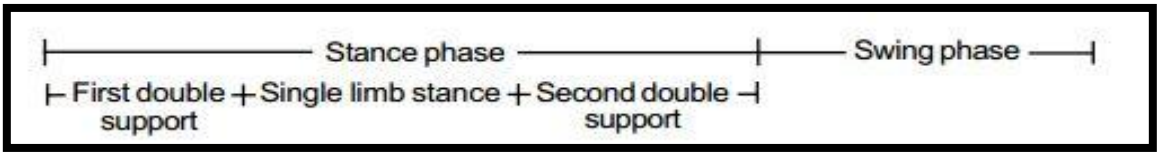
CHAPTER 2
LITERATURE REVIEW

The literature review is a process, reviewing written and published knowledge on a topic which is included in the research through books, journal, thesis and other resources that can be applied which is related to knee braces.

2.1 Gait Cycle

Gait cycle is a term that describes the patterns of motion that make up the gait, or the way in which one walks or runs. Scientists study the gait cycle to learn about the movement of various animals, while physical therapists have often studied it in order to detect muscle or bone problems in patients. While walking seems like a simple task, it is actually divided into several different actions or phases and requires the proper coordination of many muscles and bones. A comprehensive understanding of the gait cycle of humans or of other animals requires a deep understanding of all of these factors.

The gait cycle is composed of three primary phases, referred to as the stance, swing, and double support phases. The time in which the front foot is on the ground is referred to as the stance phase or support phase. The stance phase is initiated when the heel of the forward limb strikes the ground; it ends when the toe of the same limb is lifted. The swing phase or unsupported phase, on the other hand, starts when the toe of that limb is lifted and continues for the duration of that limb's time in the air. The double support phase occurs during the brief period during which both limbs are on the ground.



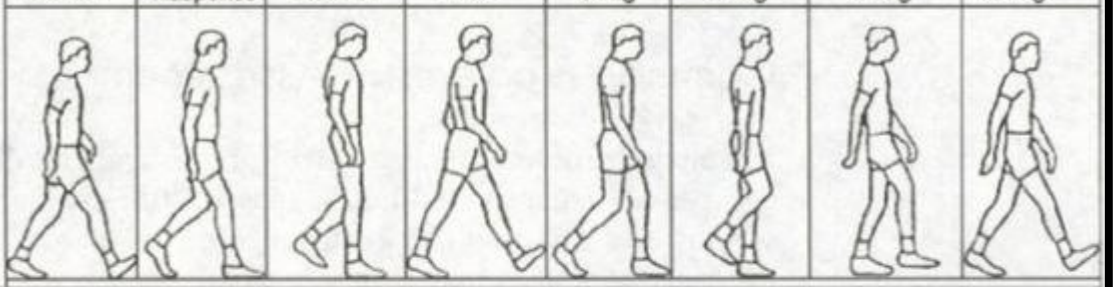
	Initial Contact	Loading Response	Mid-stance	Terminal stance	Pre-swing	Initial swing	Mid-swing	Terminal swing
								
Hip	30° flexion	Extending to 5° flexion	Extending to neutral	10° of hyper extension	Neutral extension	20° Flexion liopsoas	30° Flexion	30° Flexion
Knee	Full extension	15° Flexion	Extending to neutral	Full extension	35° Flexion	60° Flexion	From 60° to 30° flexion	Extension to 0°
Ankle	Neutral heel first	15° Plantar flexion	From plantar flexion to 10° Dorsi flexion	Neutral with tibia stable and heel off prior to initial contact of opposite foot	20° Plantar flexion	10° Plantar flexion	Neutral	Neutral

Figure 2.1: The normal gait cycle of body. Vaughan, Davis, & O'connor, (1992)

By referring Figure 2.1 the stance and swing phases of the gait cycle are further divided into several sub-phases. The stance phase is divided into the points at which the heel strikes the ground, the foot is flat on the ground, and the toe leaves the ground. The swing phases are divided into the acceleration phase, in which the moving limb gains speed after leaving the ground, and the deceleration phase, in which the limb slows down and returns to the ground. All of these phases and sub-phases together make up the gait cycle as a whole.

These divisions or phases are the primary parts of the gait cycle, but they are far from being the only important concerns in a study of the cycle. At any given point in the cycle, different muscles are in use and different joints are bent and straightened. The positions of the hips, knees, ankles, and feet are all highly important. A skilled physical therapist can often diagnose problems in particular muscles, bones, or joints based on, or at least supported by, an analysis of an individual's particular gait cycle. Factors such as the position of the muscles, position of the joints, and external concerns such as terrain and gravity are all necessary to draw such conclusions from an individual's walk.

In other research, traditionally the gait cycle has been divided into eight events or periods, five during stance and three during the swing. According to (Christoper L et al, 1999), the names of these events are self descriptive and are based on the movement of the foot. In the traditional nomenclature, the stance phase events are following:

a) Heel strike initiates the gait cycle and represents the point at which the body's center of gravity it at its lowest position.
b) Foot-flat is the time when the plantar surface of the foot touches the ground.
c) Mid stance occurs when the swinging (contralateral) foot passes the stance foot and the body's center of gravity is at its highest position.
d) Heel-off occurs as the heel, loses contact with the ground and push off is initiated via the triceps muscles which plantar flex the ankle.
e) Toe-off terminates the stance phase as the foot leaves the ground.

The swing phase events are as follows:

a) Acceleration begins as soon as the foot leaves the ground and the subject activates the hip flexor muscles to accelerate the leg forward.
b) Mid swing occurs when the foot passes directly beneath the body, coincidental with mid stance to the other foot.
c) Deceleration describes the action of the muscles as they slow the lag and stabilize the foot in preparation for the next heel strike.

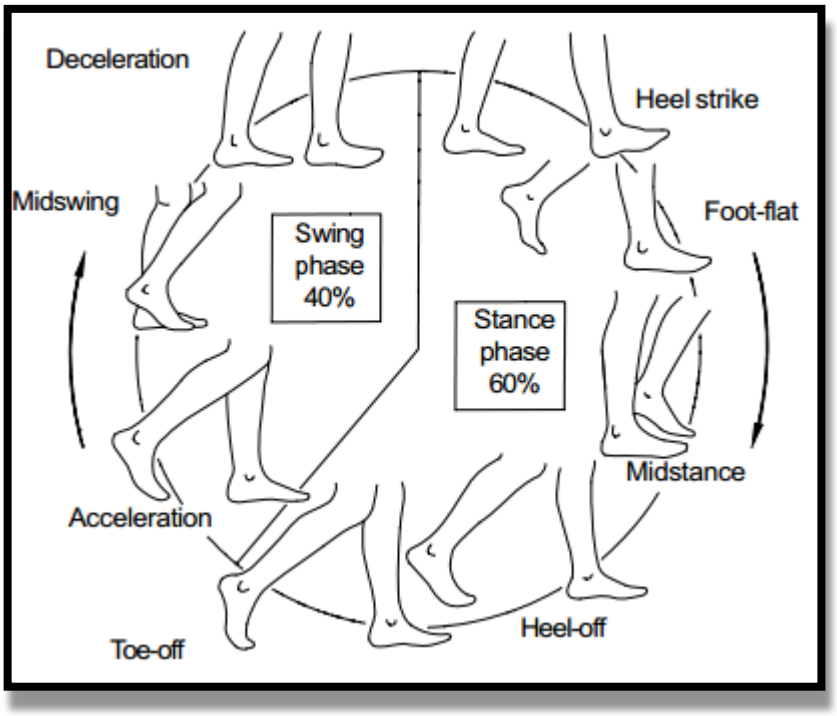


Figure 2.2: The traditional nomenclature for describing eight main events, emphasizing the cyclic nature of human gait. Vaughan, Davis, & O'connor, (1992)

The traditional nomenclature best describes the gait of normal subjects. However, there are a number of patients with pathologies, such as ankle equines secondary to plastic cerebral palsy, whose gait cannot be described using this approach. An alternative nomenclature is shown in the lower part of Figure 2.2. There are eight events, but these are sufficiently general to be applied to any of gait:

a) Initial contact (0%)
b) Loading response (0-10%)
c) Mid stance (10-30%)
d) Terminal stance (30-50%)
e) Press wing (50-60%)
f) Initial swing (70-85%)
g) Mid swing (70-85%)
h) Terminal Swing (85-100%)

The study's aim is to provide an assistive device for human leg movement; therefore it is important to know the pattern of gait cycle. Generally, the pattern or profile of the gait cycle of normal walking condition is identical, however, if a joint involved in the gait cycle is stiff and not properly functioning. There are three joints of the lower extremity that contribute to the profile of leg movement; hip joint, knee joint and ankle joint. Each of the joint has different profile of angle as shown in Figure 2.3a.

Electro goniometry represents a simple and reliable method for measuring joint motion during gait (Figure 2.3b). The most frequent methods of presenting such data are as figures of total joint excursion during gait, as a plot of joint angle against time, or as angle/angle diagrams. The gait laboratory has a 10-meter long walkway, including acceleration and deceleration distances. Two photocells with 5.5 m intervals, self-aligning electro-goniometers, a computer, and a plotter constitutes the equipment.

(a) **(b)**

Figure 2.3 (a) and (b): Location of each joint angle and electro goniometry method experiment to shown human walk profile.

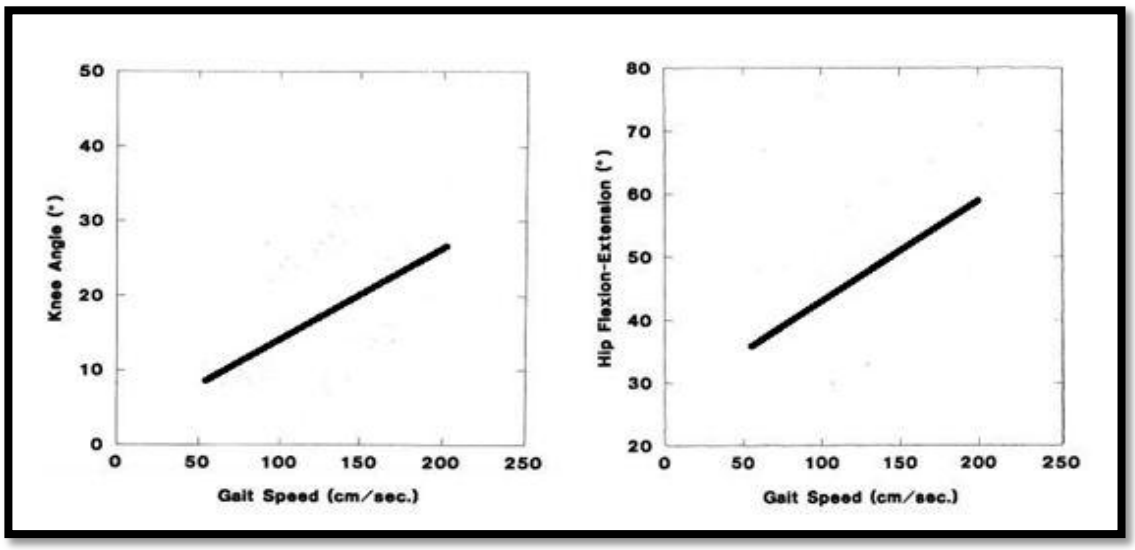


Figure 2.4: Diagram showing the relation between gait speed and knee angle and hip flexion extension

As the state of (Tommy O, 1994), the measurements were performed between the two photocells. Potentiometers with self aligning exoskeleton were used. Heel strike was indicated by means of a manual switch. Basic temporal gait parameters and joint angle data were collected during slow, normal, and fast gait. The subjects had to walk between the photocells 13 times, 10 times without goniometry, and 3 times with goniometry. The mean of the three goniometry measurements was calculated for each joint angle parameter. The subjects were asked to walk at three self-selected gait speeds: slow, normal, and fast. Figure 2.4 shown result of the relation between gait speed and knee angle and hip flexion, extension by using electro goniometry experiment for measuring joint motion during gait.

2.2 Anatomy of the Knee

To improve the design of knee braces, must have a knowledge about anatomy of the knee. According to Niitsu,(2013), the knee is one of the largest and most complex joints in the body. The knee joins the thigh bone (femur) to the shin bone (tibia). The smaller bone that runs alongside the tibia (fibula) and the kneecap (patella) are the other bones that make the knee joint.

Tendons connect the knee bones to the leg muscles that move the knee joint. Ligaments join the knee bones and provide stability to the knee:

a) The anterior cruciate ligament prevents the femur from sliding backward on the tibia (or the tibia sliding forward on the femur).

b) The posterior cruciate ligament prevents the femur from sliding forward on the tibia (or the tibia from sliding backward on the femur).

c) The medial and lateral collateral ligaments prevent the femur from sliding side to side.

Two C-shaped pieces of cartilage called the medial and lateral menisci act as shock absorbers between the femur and tibia. Numerous bursae, or fluid-filled sacs, help the knee move smoothly.

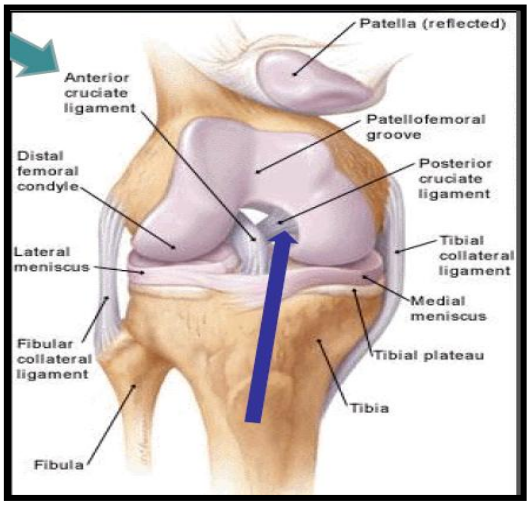


Figure 2.5: Knee Structure. Gillquist & Messner, (1999).