EXPERIMENTAL SETUP AND BIOMECHANICS MEASUREMENT OF KNEE PADS

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ABSTRACT

Despite the important role knee pads have in protecting the knee cap, little is known about their effect on person who wearing it. Most people especially sports player, the army and construction worker do not like to wear knee pad at a long period time because it kind of restricting their movement and feel uncomfortable. Most knee pads in the market are poorly design especially in the straps part because after so much movement like walking or running, the knee pads just lose the traction and falls down to the ankle. Furthermore, people have to wear the knee pad very tightly so that the knee pad will not lose the traction and knees have a tendency to wet with sweat. Once the knees are sweating and then remove or pull down the pads, there will be a sudden drop of temperature at the knees is neither feel comfortable nor healthy. The following area was investigated,to analyze the effect of force during gait (walking and running) acting on different type of knee pad (commercial and prototype knee pad) on knee human joint and also to analyze the muscle activity reaction of knee pad in gait aspect and comfort with different type of knee pad. Statistical Analysis was performed on the slope on RMS EMG Data and the average mean resultant force from force plate. Paired t-test and Wilcoxon Signed Rank test was performed and the result constantly gives the p-value is greater than 0.05. The null hypothesis will be accepted the $p \geq 0.05$ thus from the result the null hypothesis was accepted. It shows that between wearing three different kinds of knee pad, there are no significant effect on muscle activity and average mean force plate data. The results on showing between wearing and not wearing knee pad also the same, which were no significant effect between them.

ABSTRAK

Selain daripada kegunaan pad lutut sebagai ketahanan kepada lutut daripada kecederaan, tidak banyak yang diketahui tentang kesan pad lutut terhadap pemakainya. Kebanyakan pemakai pad lutut terutamanya pemain sukan, tentera dan pekerja pembinaan tidak suka memakai pad lutut dalam tempoh masa yang lama kerana boleh menyebabkan pergerakan mereka terganggu dan mereka akan merasa tidak selesa memakainya. Kebanyakan pad lutut di pasaran selalunya direka dalam keadaan yang tidak berapa elok terutamanya di bahagian tali di belakang lutut dan selalunya pad lutut akan mudah tertanggal hingga jatuh ke bahagaian betis. Tambahan pula, kebanyakan pad lutut haruslah dipakai ketat dan pad lutut yang terlalu ketat akan menyebabkan pemakai tidak selesa memakainya. Apabila pad lutut dibuka, lutut akan berpeluh dan perubahan mendadak terhadap suhu lutut akan menyebabkan kemudaratan terhadap kesihatan lutut. Untuk projek ini, kajian dilakukan terhadap kesan daya terhadap lutut semasa berjalan dan berlari apabila memakai 3 jenis pad lutut yang berbeza dan juga kesan terhadap aktiviti otot dalam terma keselesaan apabila memakai 3 jenis pad lutut yang berbeza. Analisis statistik telah dilakukan terhadap cerun garis regresi data EMG dan juga purata min daya paduan untuk plat daya. Paired t-test dan Wilcoxon Signed Rank test juga dilakukan dan keputusan eksperimen menunjukkan nilai p sentiasa lebih besar daripada 0.05 dan hipotesis null akan diterima apabila nilai p lebih besar dari 0.05. Hipotesis null telah diterima dan ini menunjukkan bahawa tiada kesan signifikan terhadap pemakai apabila memakai pad yang berbeza dalam terma daya dan aktiviti otot

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LIST OF SYMBOL

N	Newton
α	Slope
mV	milivolt
r	regression

LIST OF ABBREVIATIONS

EMG	Electromyography
KP 1	Kneepad 1 (Prototype Kneepad)
KP 2	Kneepad 2 (Coconut Fiber Kneepad)
KP 3	Kneepad 3 (Kenaf Fiber Kneepad)
P value	Probability Value
EMG 3	Electromyography 3 (Gastrocnemius Outer Head)
EMG 4	Electromyography 4 (Gastrocnemius Inner Head)
Ho	Null Hypothesis
H1	Alternate Hypothesis

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter will describe about the background, problem statement, objectives and scope of the study. From the background of the study, it comes out the problem statement and from the problem statement; the purpose of this study can be identified. This study will be based on the objective that have been determined and is limited by the scopes.

1.2 BACKGROUND

Knees take a beating in sports and in some jobs. Between running, stopping, jumping and bending, knees work harder than most parts of the body. Protecting knees is imperative for all people. Healthy knees improve performance and longevity, in addition to saving money. Knee pads are the best way to protect knees, as they absorb the blow when someone dives during a game, or has to be on the ground for work. According to the findings of an American Journal of Epidemiology study posted on the Bastyr Center for Natural Health website, knee pads can play huge role in preventing sport injuries. The studies also showed that using knee pads helped a group of young athletes post a 56 percent decrease in the risk of suffering knee injury. Knee pads prevent breaks when the kneecap makes contact with a hard floor or wall, whether it be in sports or on job.

There are two roles of knee pads, one is insulation and second is brake. The part of knee is very easy to catch cold which there are many knee disease associated with knee got cold especially in the mountains, where the breeze is very cold. So by wearing knee pad the part of leg muscles will feel comfortable when leg cooling, the facts that knees are getting cold at this time, the knee pads of insulation effect can be demonstrated.

The knee is the central intersection of the upper and lower leg bones, there are two menisci in the head of the knees and behind its patella, patella extrude by two muscles, suspended in front of leg interchange so this knee part is easy to slide. In ordinary life, because of without outside influence and violent activities, the patella in knee part can carry out ordinary small area of activities. By wearing knee pads, it can held movement of patella within a certain range in order to ensure that it does not easily injured. The above information introduce is a mild measures to protect the knee when the knee was not injured, the use of the severe breaking knee pads can reduce the bending of the knee after knee injury. From the thigh to the calf to keep in a straight line to reduce the bending of the knee, so the is recommended to use the mild brake kneepads in mountaineering activities. Another one is fairly robust, ordinary bundles and rarely occur in store. Knees can't usually bent after this kneepads, properly tied, foot to keep in a straight line, so it is very suitable for severe brake when the knee injury and due to the airtight of the material, it is not suitable for common protection of the knees. (Ryan Gargulynski, 1996).

Most people especially the sports player and industrial worker tends not to wear knee pads for protecting the knees because knee pads is kind of restrict the movement of muscle and circulation of the blood. This project is to identify which material is the most comfortable and the design that have maximum comfort aspect. The knee pads need to stay in place, be comfortable, protect the knee against various kind of surface. All this aspect is important to reduce the risks of knee injuries.

1.3 PROBLEM STATEMENT

Despite the important role knee pads have in protecting the knee cap, little is known about their effect on person who wearing it. Most people especially sports player, the army and construction worker do not like to wear knee pads in a long period time because it kind of restrict their movement and feel uncomfortable. Most knee pads in the market are poorly design especially in the straps part because after so much movement like walking or running, the knee pads just lose the traction and falls down to the ankle. Furthermore, people have to wear the knee pad very tightly so that the knee pad will not lose the traction and knees have tendency to wet with sweat. Once the knees are sweating and then remove or pull down the pads, there will be a sudden drop of temperature at knees is neither feel comfortable nor healthy.

The following three areas were investigated, the stress distribution acting on the knee pads, the overall comfort of the kneepads and the effect of the kneepads on long term gait patterns. The results of this research will provide an understanding of how knee pads affect people movement, gait aspect and also comfort aspect. This new information could be used to improve the design of the knee pads and minimize any undesired effects.

1.4 OBJECTIVES

The main objectives of this project is:

1. To analyze the effect of force during gait (walking and running) acting on different type of knee pad (commercial and prototype kneepad) on knee human joint.
2. To analyze the muscle activity reaction of knee pad in gait aspect and comfort with different type of kneepad.
3. To determine the effect of knee pad in gait aspect and comfort with different design and different kind of material of knee pad.

1.5 SCOPE OF PROJECT

The scope of this project are as follows, four different phases which are walking with knee pads, walking without kneepads, runnning with kneepads and running without kneepads. Sample size is 20 people and must wear their own sport shoes to ensure proper fit.Sample size should met the followimg requirements:

1. Ages of 18 and 25.
2. Involve any kind of sports
3. Be able to jog for 10 minutes at a self selected pace.
4. Not have any obvious gait abnormalities.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, in order to understand how knee pads affects the gait aspect, it is necessary to understand the gait pattern, the muscle movement during walking and running and also different properties of gait with how to measure them. A simple explanation on how the gait analysis is perform, how force plate is used for biomechanics measurement and also how electromyography (EMG) will perform the pressure distribution and analyze the muscle movement.

2.2 GAIT ANALYSIS

Walking is simply the action of putting one foot ahead of the other to cause the body to move in a desired path. "As the body moves forward, one limb serves as a mobile source of support while the other limb advances itself to a new support side. Then the limb serves as a mobile sources of support while the other limb advances itself to a new support site. Then the limbs reverse their roles. For the transfer of body weightfrom one limb to another, both feet are in contact with the ground. This series of events is repeated by each limb with reciprocal timing until the person's detination is reached" (Perry, 1992). This sequence of events describe human gait. A gait cycle is a single sequence of this function.

Within this sequence, there are multiple phases that contribute to a single cycle. Starting with the right leg, the right heel makes contact with ground (initial due stance) while the left foot is still on the ground (initial dual stance) while the left foot is still on the ground. The left foot then leaves the ground and the weight of the person is supported on the right foot (single limb stances) until the left heel makes contact with the ground (swing) and the gait cycle is completed when the right heels makes contact with the ground again. Figure 2.1 illustrates the breakdown of the gait cycle for both left and right leg.

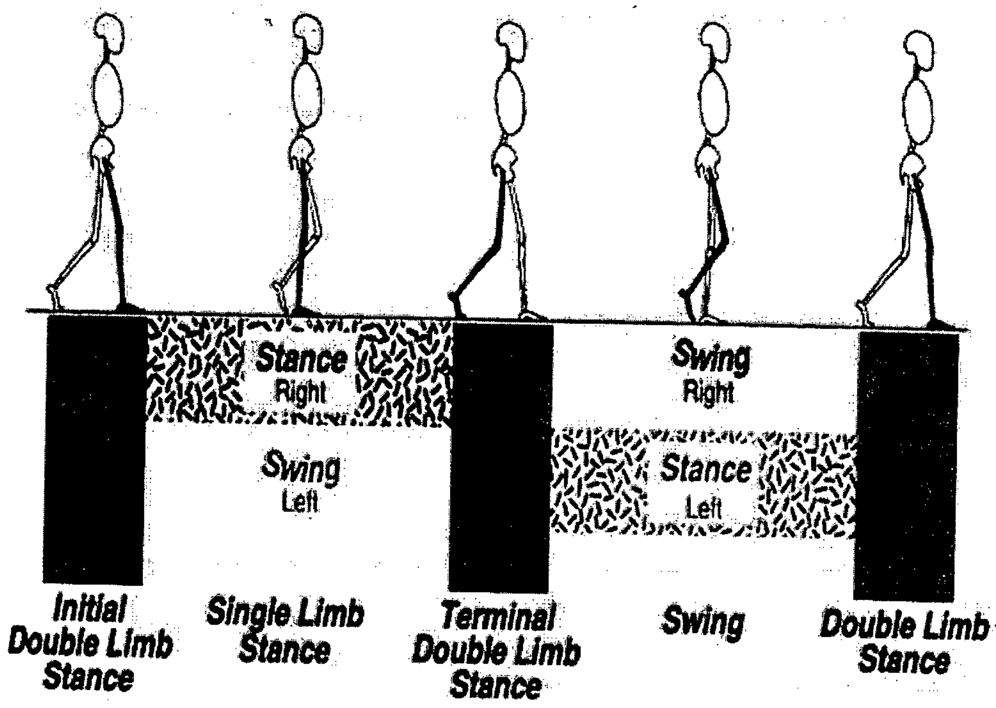

Figure 2.1 : The Gait Cycle

(Source: Perry,1992)

Table 2.1: Percent of time spent in each phase of cycle

Term	Definition	% Gait Cycle
Initial Duel Stance	Time from right heel to left foot toe off	10
Single Limb Stance	Time when only the right foot is touching the ground	40
Terminal Duel Stance	Time from left heel strike to right toe off	10
Swing	Time when the right foot is in the air	40

(Source: Perry 1992)

Based on the figure 2.1, when walking the number of steps a person takes in a minute is define as cadence. Normal free gait averages 82 meters per minute, ±7%, and varies in cadence from 101 to 122. As people grow older the variance in gait parameters increases. Women tend to have a higher cadence than men by 6 to 11 steps per minute, however men are on average 5% faster than women and have a longer stride length (1.46 m) than women (1.28m). This is a result of having longer legs on average, longer legs result in longer stride length and higher walking speeds. This is also observable in children where they are constantly growing and their stride length increases significantly until approximately age 11.

The gait cycle is separated into two distinct periods of stance and swing. Functional tasks include weight acceptance and single limb support during stance and limb advancement during swing. The stance period of the gait cycles includes initial contact, loading response, midstance, terminal stance and preswing. The swing periods include initial swing, midswing and terminal swing.

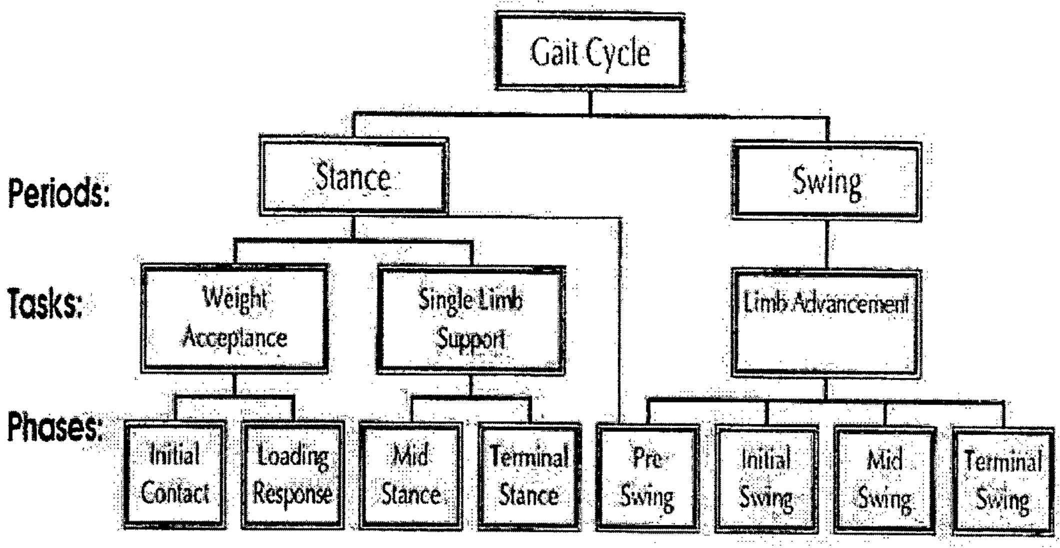

Figure 2.2 : Period of Gait Cycle

(Source : Kerrigan, Scahufele, Wen 1998)

Many methods are used to analyze gait. Kinetic, kinematic, temporal and spatial methods are commonly used. In kinetics, forces that exist between a person and an object are measured and analyze. In gait these are generally the ground reaction forces. By using inverse dynamics, forces and moments generated by the nuscles, across the joint it can be calculated. In a kinematic analysis, limb and joint positions, velocities and accelerations independent of forces are measured and analyzed. Often times in gait analysis one gait cycle is examined due to the repetitive nature of gait.A temporal analysis examines kinetic or kinematic data as a function of time, or examines the time frequency of a specific task. In walking, the time of one gait cycle is described as a stride interval and multiple successive intervals are recorded over a period of time creating a stride interval time series. A spatial analysis examines kinetic or kinematic data as a function of position, or determines the position of a specific body part during repetitive motions. The minimum foot clearance of a foot during a gait cycle measured over multiple cycles or the maximum knee flexion angle are good examples of a spatial analysis. (Winter, 1991)

In the gait cycle the timing of every phase is important. According to J.M. Hausdorff, Z. Ladin and J.Y. Wei, 1995, in their journal "Footswitch System for Measurement of the Temporal Parameter of Gait", measurement of the beginning and end of footfall is an essential component of gait analysis. Traditionally this is performed by using force plates however one is not able to measure a high number of successive foot falls using this method. In order to do this a mobile system is needed that can accurately measure the time of each footfall. In 1994, Hausdorff et al. developed a foot switch system that consisted of two foot switches, one at the heel of the foot and one at the ball of the foot that were, "connected in parallel, and essentially act as one large sensor." This setup senses when the foot makes contact with the ground and when the foot leaves the ground. In comparison to measurements made using a force plate, the foot switch system proved to be a reliable system for capturing repeated gait cycles. Using his foot switch system Hausdorff *et al* (Hausdorff 1995) published a paper that presented a new technique for analyzing gait patterns. Using a detrended fluctuation analysis (DFA), a modification of a root-mean square analysis, a scaling exponent α is calculated. Long range correlations in the gait patterns were discovered and showed evidence of a fractal pattern. In a detrended fluctuation analysis the scaling exponent (α) can be calculated in the following manner. The time series is first integrated where y(k) is the integrated time series

$$\boldsymbol{y\,(k) = \sum_{t=1}^{k} [I(i) - Iavg}$$

I(i) is the ith stride interval

$Iavg$ is the average stride interval

k equals to the total number of stride interval

Next, the time series is divided into equal length data records (n) and a best fit line is drawn for each record. Within each record, a least square line is drawn and the y-coordinate of the line is designated by yn(k). The average fluctuation of y(k) around the locally best-fit line for each block size can be calculated by the

$$F(n) = \sqrt{\frac{1}{N}\sum_{k=1}^{N}[y(k) - yn(k)]^{\wedge}2}$$

This sequence is repeated for all n. Typical values for n are 4 to (N/4), where N is the total number of strides in the stride interval series. A log-log plot of F(n) vs. n is created and the slope of line is α (Hausdorff, 1995).

Table 2.2 : α coefficient and its significance

α coefficient	**Significance**
$0 < \alpha < 0.5$	Power law anti correlations
$\alpha = 0.5$	White Noise
$0.5 < \alpha < 1$	Long Range Power Correlation
$1 < \alpha < 1.5$	Correlation exist but are no longer of power low type
$\alpha = 1.5$	Brownian Noise, the integration white noise

(Source : Hausdorff, 1995)

2.3 WALKING AND RUNNING ON A FORCE PLATE

Force plate are commonly used in biomechanics laboratories to measure ground forces involved in the motions of human or animal subjects. By using force plate, the force wave form can be displayed and measured directly to demonstrate either qualitative or quantity relations between force, acceleration and displacement. A force plate is simply a metal plate with one or more sensors attached to give an electrical output proportional to the force on the plate. The sensor can either be a strain gauge or a piezoelectric element. At frequencies less than about 100 Hz, the output of a force plate is accurately proportional to the applied force and can be monitored on a storage oscilloscope or fed to a data acquisition system for display and further analysis. Force plates are generally not suited for studying impacts of duration less than a few ms, since most plates are large and flexible and vibrate at a frequency of about 400 Hz. These vibrations are normally of no consequence in biomechanics applications since they are strongly damped if foot contact is maintained for several ms or more. A typical application of a force plate is to measure the ground reaction force on each foot while walking. The vertical component of the force rises from zero to a maximum value of about *Mg*, then drops below *Mg*, then rises again to about *Mg*, then drops to zero. (Cross, 1998). The main retarding force in both walking and running arises from the fact that the front foot pushes forward on the ground, resulting in an impulse that is equal and opposite the impulse generated when the back foot pushes backwards. This can be shown in Figure 2.4:

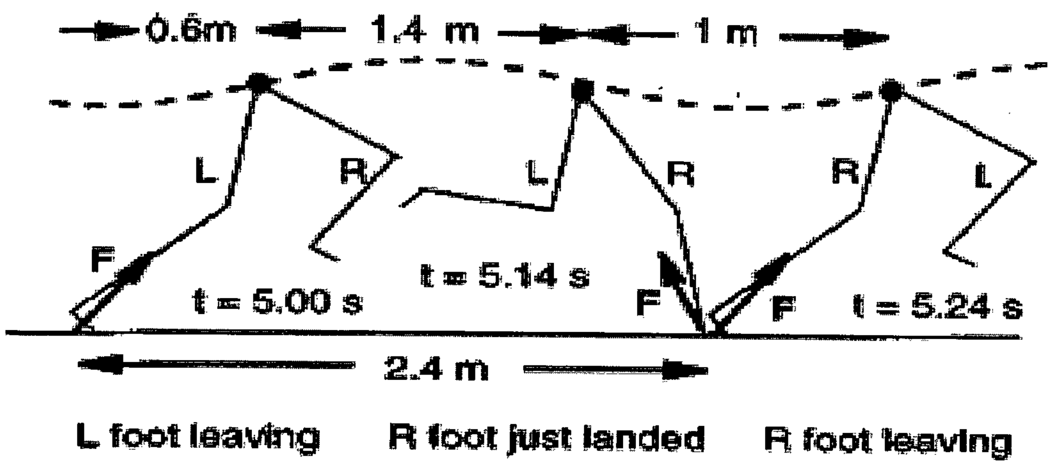

Figure 2.4 : Ground forces when running and the vertical displacement of the centre of mass (dashed line). Also shown are typical distances and times when running at 10 ms-1.

(Source: Cross,1998)

The instantaneous walking speed therefore fluctuates, but it is average speeds remain constant, then the average horizontal forces remains zero. The retarding force can therefore be attributed to a frictional force, between in front foot and the ground that prevents the front food sliding forward along the ground.

2.3.1 Walking Wave Forms

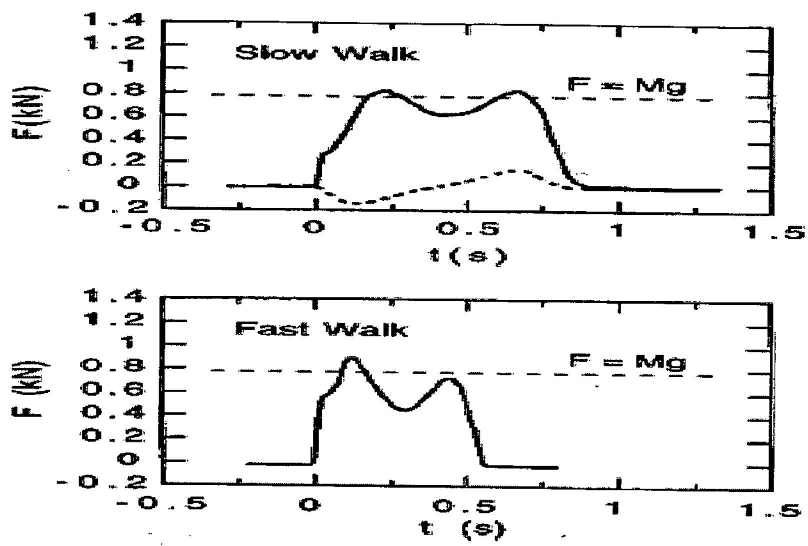

Figure 2.5 : The wave forms observe when walking (a) at a slow pace and (b) at fast pace. The dotted line represent the horizontal component of the ground force, in the direction of the gait.

(Source : Cross,1998)

2.3.2 Running Wave Forms

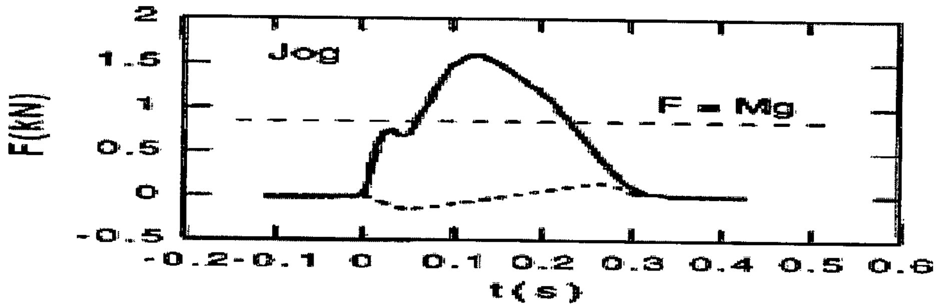

Figure 2.6: The wave form observed when jogging. The dotted line represents the horizontal components of the ground forces.

(Source: Cross, 1998)