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# EFFECT OF KNEE PAD ON KICKING A BALL AND GAIT ANALYSIS

K. Kadirgama
Z. Taha
A.R. Ismail
Azrul Hisham
A. Zulkifli
Nasrul Hadi
Zulfika

Sport & Human Engineering Focus Group,
Faculty of Mechanical Engineering,
Universiti Malaysia Pahang

## Abstract

Wearing kneepads is the best defence against occupational knee injury. It has been reported that the use of knee pads can reduce injuries and increase performance. Knee pads provide protection by disbursing pressure on the knees and preventing puncture wounds. This study focuses on the effect of knee pads on muscle activity and gait analysis. As a case study, measurement of muscle activities whilst kicking a ball was conducted. The normalized mean of the EMG data shows that the vastus lateralis and vastus medialis muscles are highly active when wearing a knee pad. Gait analysis was conducted on six subjects with and without wearing knee pad. Results shows that wearing knee pads increases the force (950 ~ 1150N) acting on the ground, compared with not wearing knee pads (800 ~900 N).

## Introduction

The most important means of ball progression in soccer is kicking. The standard kicking technique comprises of accuracy, distance and speed of execution. Therefore, some relevant research has included a study of the kinematics of punt kicking [1] and electromyography of the soccer kick [2]. The most common injuries experienced by players in soccer are hamstring strains, knee and groin injuries. Most injuries are equally distributed between both sides of the body, although quadriceps strains are more common on the dominant kicking leg [3]. Factors that may explain the relatively higher incidence of hamstring and groin injuries include greater distance of sprinting during an average effort, the less predictable flight from the ball, greater length of the playing arena, repetitive loads in kicking and longer duration of games. Kicking almost certainly increases the rate of quadriceps strains. The lower-limb motions are very important for human daily activities, such as sitting down, squatting, walking, ascending and descending stairs. It is sometimes difficult for physically weak persons (elderly, disabled, and injured persons) to perform daily lower-limb motions [4]. Flexion/extension motion of a human hip joint is mainly actuated by the muscles of iliacus, psoas, rectus femoris, tensor fasciae latae, biceps femoris, and semitendinossus [5]. Many of these muscles are bi-articular muscles, such as the muscle of rectus femoris biceps femoris and semitendinossus, since they work on both hip and knee joint. Flexion/extension motion of a human knee joint is mainly actuated by the muscles of biceps femoris, semitendinossus, gastrocnemius, rectus femoris, vastus lateralis and vastus medialis. Most of these muscles are bi-articular muscles such as the muscles of biceps femoris, semitendinossus, and rectus femoris since they work on both hip joint and knee joint, and the bi-articular muscle of gastrocnemius work on both knee joint and ankle joint [6,7]. Dorsiflexion/plantarflexion motion of a human ankle joint is mainly actuated by the muscles of gastrocnemius, soleus, and tibialis anterior. The muscle activity levels can be described by EMG signals [8].

Walking is simply the action of putting one foot ahead of the other to cause your 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 site. Then the limbs reverse their roles. For the transfer of body weight from one limb to the other, both feet are in contact with the ground. This series of events is repeated by each limb with reciprocal timing until the person's destination is reached"[9]. This sequence of events describes 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 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 stance) until the left heel makes contact with the ground (terminal dual stance). The right foot then leaves the ground (swing) and the gait cycle is completed when the right heel makes contact with the ground again. 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 analyzed. In gait these are generally the ground reaction forces. By using inverse dynamics, forces and moments generated by the muscles, across a joint, can be calculated [10]. In a kinematic analysis, limb and joint positions, velocities and accelerations independent of forces are measured and analyzed. Often 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 [10]. In this study, experiments were performed to identify the relationship of muscle activity (Vastus lateralis and Vastus medialis) with and without wearing knee pad when kicking a ball (knee joint extension) and during gait.

## Methodology

The six subjects were aged between 22 to 28 and did not have any obvious gait abnormalities. The subject was videotaped while kicking the ball as shown in Figure 1 (a). The player was instructed to kick a football towards an imaginary target. The surface EMG of the major muscle groups was acquired using MESPEC 4000 Telemetry. The MESPEC4000 is an electromyography (EMG) radio telemetry system, which comprises of an EMG unit, radio telemetry transmitter and receiver used to capture data on muscle activation levels during tests via telemetry. The EMG data was acquired at 500 Hz and sensitivity of 1μV. Eight channels of EMG data were acquired, i.e. right hamstring, left hamstring, right quadriceps, left quadriceps, right gluteal, left gluteal and rectus abdominus muscle groups as shown in Figure 2 (b). In order to analyze the EMG signals, features should be extracted from the raw EMG data as shown in Figure 2. Normalized by mean has been applied as a feature extraction method of the EMG signals in this study. Gait was measured with a multi axis force plate (AMTI OR6 series) and six different subjects were chosen for the experiment. The test procedure for measuring gait consisted of two different phases; walking with the knee pads and walking without the knee pads. All subjects in this procedure wore their own shorts and were barefooted. The data recorder was carried by the person administering the test so no extra loads were carried by the subjects.

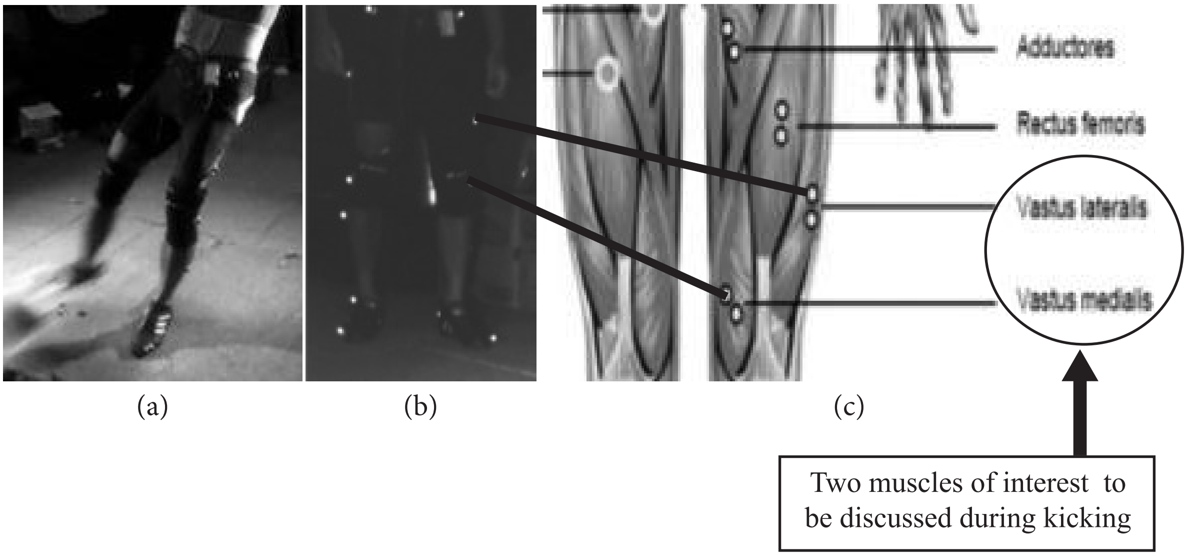


**Figure 1:** (a) Subject kicking the ball; (b) subject with the EMG system; (c) Muscles of interest

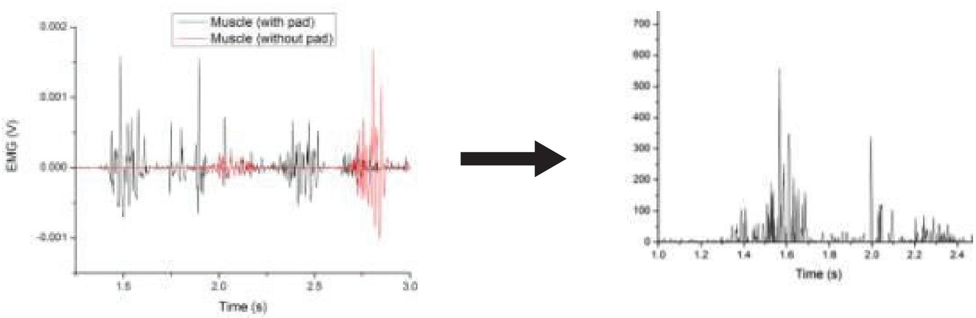


**Figure 2:** EMG raw data convert to normalized by mean

## Results and Discussion

It was observed that the Vastus lateralis and Vastus medialis ( Figure 1) are highly activated when wearing a knee pad compared with not wearing one.(Figures 3 and 4). McCrudden and Reilly [9] have compared EMG findings on punt kicking a soccer ball with drop kicking. Bollens, De Proft & Clarys [2] divided the soccer kick into six phases and measured EMG activity for six muscles in the kicking leg during these phases. They called their phases: (1) first step; (2) second step; (3) loading phase; (4) swinging phase; (5) ball impact; (6) follow- through. They found that vastus medialis and lateralis contractions were maximal during the loading phase, at which time the knee was still flexing. They called this part the 'soccer paradox' where a substantial amount of muscle work appears to be done eccentrically during soccer kicking. The rectusfemoris, vastus lateralis and vastus medialis muscles are mainly activated for knee joint extension [10]. This phenomenon is known as the force-length relationship or the length-tension curve which relates the strength of an isometric contraction to the length of the muscle at which the contraction occurs. Muscles operate with the greatest active force when close to an ideal length (often their resting length).

When stretched or shortened beyond this (whether due to the action on the muscle itself or by an outside force), the maximum active force generated decreases [11]. This decrease is minimal for small deviations, but the force decreases rapidly as the length deviates further from the ideal. As a result, in most biological systems, the range of muscle contraction will remain on the peak of the length-tension curve, in order to maximize contraction force (a notable exception is cardiac muscle which functions on ascending limb so it can increase force when stretched by an increase in preload-Starling's law) [11]. Due to the presence of elastic proteins within a muscle (such as titin), as the muscle is stretched beyond a given length, there is an entirely passive force, which opposes lengthening. Figure 5 shows a normalized stride with force obtained with the kneepad and without knee pad from the force plate. It shows that the force pattern is almost the same with and without knee pad from force plate. The force seems slightly higher (1150 N) when wearing a knee pad. Tests on the six subjects showed there were no significant changes in the correlation coefficient between wearing knee pads and not wearing knee pads. Hence, this result could mean that there are no variations in the gait pattern or that there were enough inaccuracies in the measurement to cause the α values to vary. As stated in [12] normal human gait has an α value between 0.5 and 1 with 0.75 being the theoretical normal value.  Trials with knee pads and trials without knee pads were compared as well as data from the left foot compared to the right foot. The tests showed consistently that no significant differences were found between the trials with knee pads and the trials without knee pads as well as left foot compared to right foot. To add further creditability to this study the findings of this study coincide with studies performed by West et al. In his study, West states that the stride-interval time series is fractal and there are long-time correlations in walking. In the studies performed by Hausdorff [12], he had his subjects walked for around 9 minutes creating a time series of almost 500 foot falls. His findings from this study did not vary from his previous studies, it only helped to validate the length studied previously. In a study by Keenan [13] to determine how many stride intervals were needed to calculate a fractal pattern in gait he determined that only 25 successive foot falls were necessary to accurately determine the fractal pattern.

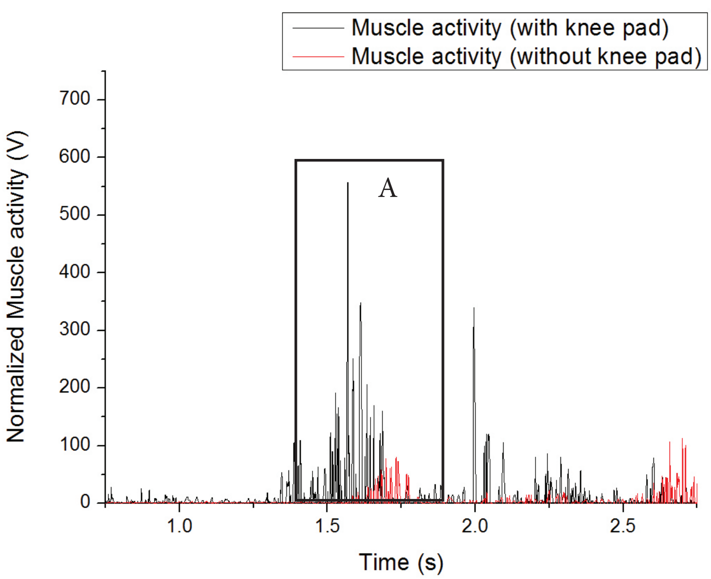


**Figure 3:** Vastus lateralis activity

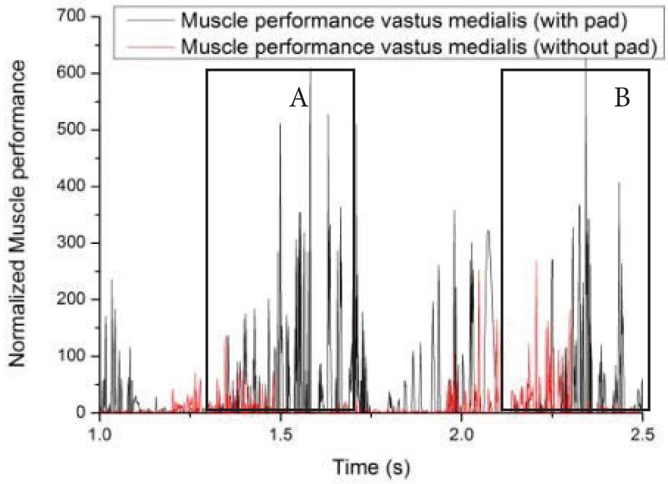


**Figure 4:** Vastus medialis activity

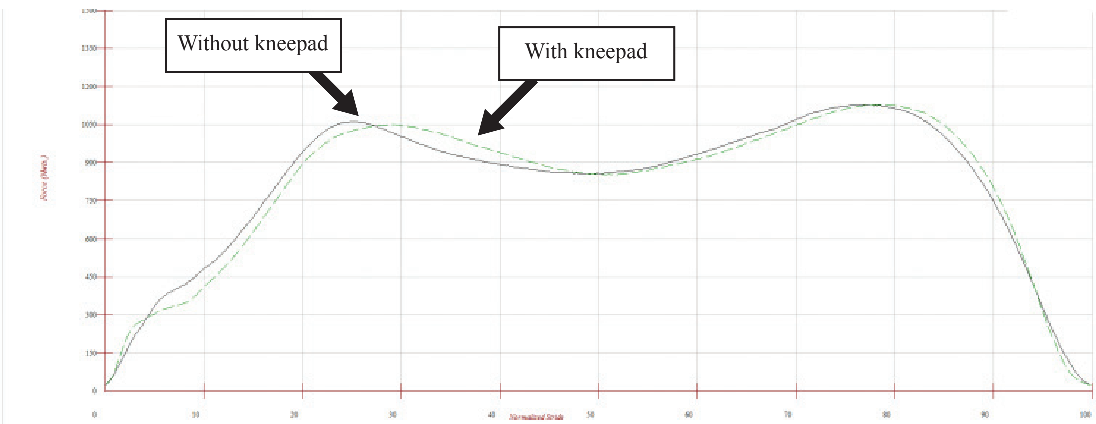


**Figure 5:** Gait analysis

## Conclusion

It can be concluded that the vastus laterlis and vastus medialis muscles are highly activated when kicking a soccer ball whilst wearing a knee pad. This phenomenon known as the force- length relationship or the length-tension curve relates the strength of an isometric contraction to the length of the muscle at which the contraction occurs. Muscles operate with the greatest active force when close to an ideal length (often their resting length). In gait analysis, there is slight difference in terms of force when wearing knee pad and without knee pad. It seems that wearing a knee pad impacts high force on the ground compared to without wearing it.

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