BIOMECHANICAL LOADING OF INSTEP KICK FOR MALAYSIAN FOOTBALLER

DAYANG KHAIRUNNISA BINTI ABANG KIPRAWI

Report submitted in partial fulfillment of the requirements for the award of Bachelor of Mechanical Engineering with Manufacturing Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2012

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL: BIOMECHANICAL LOADING OF INSTEP KICK FOR MALAYSIAN FOOTBALLER

SESI PENGAJIAN: 2011/2012

Saya, **DAYANG KHAIRUNNISA BINTI ABANG KIPRAWI (8903014-13-5930)**

mengaku membenarkan tesis (Sarjana Muda / ~~Sarjana / Doktor Falsafah~~)* ini disimpan di perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis ini adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√)

[ ] **SULIT** (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

[ ] **TERHAD** (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi / badan di mana penyelidikan dijalankan)

[√] **TIDAK TERHAD**

Disahkan oleh:

______________________	______________________
(TANDATANGAN PENULIS)	**IR AHMAD RASDAN BIN ISMAIL**
Alamat tetap:	(Nama Penyelia)
No. 133, JS1/45 MLNG HOUSING, JLN PERSIARAN PANGERAN MATUSIN, TANJUNG KIDURONG, 97000, BINTULU SARAWAK	
Tarikh: **25 JUNE 2012**	Tarikh: **25 JUNE 2012**

CATATAN: * Potong yang tidak berkenaan.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak brkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.
◆ Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara Penyelidikan atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature :
Name of Supervisor : IR AHMAD RASDAN BIN ISMAIL
Position : LECTURER
Date : 25th JUNE 2012

Signature :
Name of Second Reviewer : JASRI MOHAMAD
Position : LECTURER
Date : 25th JUNE 2012

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature	:	
Name	:	DAYANG KHAIRUNNISA BINTI ABANG KIPRAWI
ID Number	:	ME08028
Date	:	25th JUNE 2012

ACKNOWLEDGEMENT

First of all, thanks to Allah S.W.T for the blessing and for the guidance until I complete my Final Year Project 1 (FYP 1) and Final Year Project 2 (FYP 2). I would like to take this opportunity to express my gratitude and also appreciation towards everyone who have help me a lot during this period of time either directly or indirectly. I am really thankful to my supervisor, Ir. Ahmad Rasdan Ismail throughout this period of time and gave me supports, guidance and knowledge that is uncountable.

Not forgotten, big thanks to Mr. Mohd Syahrul Nizam Mohd Johar, biomechanist at National Sports Institute (ISN) Bukit Jalil for cooperation and guidance in my study. To all lecturers of Universiti Malaysia Pahang and laboratory’s person in charge, I would like to thanks all of them for giving me an opportunity to learn more with them, guided me without hesitate and encourage me more with pour as much knowledge as they can to make me understand more on job scope here in this company.

A special thanks to my beloved family and all of students under supervision of the same supervisor as me for their supports and friendship throughout this semester.

ABSTRACT

Improvements of kicking technique have to be taken care of since good kicking technique is essential for a football player. Therefore, the understanding of biomechanical loading of one of the kicking technique which is instep kick is particularly important for their training process. Biomechanics loading for double instep kick is chosen for this study. However, it is more to comparison of using knee pad or without knee pad while performing one step and two steps of instep kick. The variables from collected data will be analyzed to see the correlation towards the performance between using knee pad or without knee pad in this study. Analysis of data is done by using Silicon Pro Coach Software and statistical analysis is done by using Minitab software and SPSS. Video of subjects while performing double instep kick is analyzed by Silicon Pro Coach software whereas for statistical analysis, linear regression, multilinear regression and correlation analyzed by using Minitab and SPSS software. Through linear regression analysis, velocity and acceleration variable usable in making force equation model and distance is neglected since its having low significant value to force model. The highest velocity can be achieved when performing two step run and without using knee pad which showed 12.6061 m/s. The highest acceleration occur when the subject performing instep kick with two step run and without using knee pad, 630.31 m/s2. Then, the highest value of distance here is when performing instep kick with two step run and without using knee pad which is 48.4611 m and it shows that the biggest hip angle occurred when performing one step run and with the knee pad 140.5556 ° while the biggest knee angle occurred when applying two steps run while using knee pad 153.00 °.

ABSTRAK

Penambahbaikan teknik menendang yang harus diambil berat kerana teknik yang baik menendang adalah penting bagi pemain bola sepak. Oleh itu, pemahaman biomekanikal mengenai teknik menendang iaitu sepakan instep adalah penting terutamanya untuk proses latihan mereka. Biomekanik untuk sepakan instep dua kali larian dipilih untuk kajian ini. Walau bagaimanapun, adalah lebih kepada perbandingan menggunakan pad lutut atau tanpa pad lutut ketika melakukan sepakan instep satu langkah dan dua langkah larian. Pembolehubah dari data yang dikumpul akan dianalisis untuk melihat korelasi ke arah prestasi antara menggunakan pad lutut atau tanpa pad lutut dalam kajian ini. Analisis data dilakukan dengan menggunakan perisian Silikon Pro Coach dan analisis statistik dilakukan dengan menggunakan perisian Minitab dan SPSS. Video diambil semasa menjalankan sepakan instep dua kali dianalisis oleh perisian Silikon Pro Coach manakala bagi analisis statistik, regresi linear, multilinear regresi dan korelasi dianalisis dengan menggunakan perisian SPSS dan Minitab. Menggunakan analisis regresi linear, halaju dan pecutan boleh guna pembolehubah dalam membuat model persamaan daya dan jarak diabaikan kerana mempunyai nilai yang signifikan yang rendah untuk persamaan model daya. Halaju yang paling tinggi boleh dicapai apabila melakukan dua kali larian sepakan instep dan tanpa menggunakan pad lutut yang menunjukkan 12.6061 m / s. Pecutan tertinggi berlaku apabila subjek melaksanakan sepakan instep dengan dua langkah larian dan tanpa menggunakan pad lutut, 630.31 m/s2. Kemudian, nilai tertinggi bagi jarak ialah apabila melakukan sepakan instep dengan dua langkah larian dan tanpa menggunakan pad lutut yang 48.4611 m dan ia menunjukkan bahawa sudut pinggul terbesar berlaku apabila melakukan satu langkah jangka dan dengan pad lutut 140.5556 ^{0} manakala terbesar sudut lutut berlaku apabila melakukan dua langkah larian yang dijalankan pada masa yang sama menggunakan pad lutut 153.00 °.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

r_L	Vector from lower leg CG to knee joint centre
m_L	Mass of the lower leg
a_{hip}	hip linear acceleration vector
Δt	Time difference
SD	Standard deviation

LIST OF ABBREVIATIONS

ACL	Anterior cruciate ligament
DLT	Direct linear transformation
EMG	Electromyography
MHLA	Moment due to hip linear acceleration
SSC	Stretch shortening cycle

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Football games are one of the most popular games and team sports worldwide. Football players' kick is the crucial moment and action during the games and teams with more kicks on the target has better chance to win the game. With this, improvements of kicking technique have to be taken care of. A good kicking technique is essential for a football player. Therefore, the understanding of biomechanical loading of one of the kicking technique which is instep kick is particularly important for their training process (Manolopoulus *et al.,* 2006).

Instep kick is the most powerful kick in football. It is known that with no limitations on the run up the instep kick is the optimal kick in terms of ball velocity (Lees, 1998) and precise (Peitersen, 1998). It is a fact that the instep kick is an open kinetic link movement that has biomechanical advantages with pre-tension in swing phase that created by run up. Basically, instep is on the top of foot where the shoelaces are tied. For performing instep kick, supporting leg is placed at the side and slightly behind the ball. The kicking leg is first taken backward swing with flexed knee. Then in following forward swing, kicking leg should be carried out in whip-like manner which is forward rotation begin with hip, followed by rotation of knee and ankle. Thigh should be slow down before ball contact and the speed of ankle and toe is increase dramatically. Timely control of kicking leg is vital for quality of instep kick (Shan G. *et al.,* 2011). Kicking leg has three link kinetic chains which are thigh, shank and foot. Hip, knee and ankle is the parts that is usually been measured for biomechanical study for soccer.

Biomechanics is the study of living things, plant, animal, human biomechanics that investigate on human being and exercise and sports biomechanics include human that is involving in exercise and sports (Luhtanen, 1988). Biomechanical evaluations consist in measuring kinematics, kinetics and muscular activity of human movement (Cerulli G. *et al*., 2004). Kinematics analyzes the movement of the body and its parts. Kinetics is analysis of forces that produce motion while the muscular activity provides information about the action of the muscles that produce the necessary strength to create motion. The combination of these three is essential to identify functional alterations. Biomechanical loading in kicking for football games is important for guiding a training process.

The key success of any kick is football is actually the placement of the supporting foot means the non kicking foot. If it is improperly positioned relative to the ball, the resultant kick will be bad. However, there are actually various factors that contributed for a success of instep kick. It is depends on the distance of the kick from the goal, the type of the kick used, the air resistance and the technique of main kick which best described from biomechanical analysis. There are others factors such as training, equipment involved, injuries, role of the arm and supporting leg, conservation of linear momentum during collision, velocity of the foot, speed of the ball, accuracy of kicking, length, speed and angle involved, hip linear motion, dominant limb or preferred leg, age, position of players in the game and fatigue.

This study on double instep kick will focus on Malaysian footballer with or without knee pad that will seek for optimal variables that will contribute to succeed instep kick performance. With this study, perhaps the application of biomechanical principles to sport can improve the understanding of movement mechanisms, assess and improve performance and provide knowledge to prevent injuries.

1.2 BACKGROUND OF THE STUDY

Biomechanics is the study of living things, plant, animal, human biomechanics that investigate on human being and exercise and sports biomechanics include human that is involving in exercise and sports (Luhtanen, 1988). It is important in football games to identify and investigate their kicking actions. It may contribute to increase their performance skills and biomechanics study is usually guidance in their training process. Biomechanics can be used in any sports but for this study, it will focus on success instep kicking techniques.

Anthropometry is the measurement of human individual. It is used for identification for purpose of understanding human physical variation. Statistical data is important in ergonomics where it is about distribution of the body dimensions in the population and it is used to optimize products. For sure there are changes in life style or nutrition and it leads to changes in distribution of body dimension and it requires regular updating of anthropometric data collections.

1.3 PROBLEM STATEMENT

Biomechanics research on football games and instep kick has been studied by many of the researchers before. All of the studies relate to many aspects or factors that may contribute to successful kicking actions. Some of the researches are regarding number of trial that is necessary to achieve performance stability during soccer instep kicking, biomechanical responses of instep kick between different positions, biomechanics analysis for right leg instep kick, effects of leg muscle fatigue on instep soccer kick and many more. As been seen, instep kick is mostly chosen as research for study. Therefore, biomechanics loading for double instep kick is chosen for this study. However, it is more to comparison of using knee pad or without knee pad while performing double instep kick. The variables from collected data will be analyzed to see the correlation towards the performance between using knee pad or without knee pad in this study.

1.4 OBJECTIVE OF THE STUDY

This study was conducted on natural football field at National Sports Institute (ISN) Bukit Jalil. The objectives of this study are:

a) To conduct and analysis the human perception on instep kicking activities through survey and anthropometric data from subjects of the study;
b) To identify force equation and comparing results between subject with knee pad and without knee pad.

1.5 SCOPE OF STUDY

This study is related to biomechanics field for quantitative measurement. A double instep kick activity was chosen as there will be comparison with using knee pad or without knee pad while performing the kick. The optimum kicking value from collected data will be compared between both of the situation. Moreover, it is related to ergonomics which is well known as human factor. It is a study of how a design is fit and suitable to human body in many ways of their movement. Good ergonomics will lead to an improved performance and productivity. The experiment will be conducted at National Sports Institute (ISN) and the kicking action by the subjects will be captured by high speed camera so that it can be analyzed. Data management and analysis will be performed by using Silicon Pro Coach and the statistical analysis will be carry out by using Minitab and SPSS software. As for this study, good ergonomics essential for training programs and can decrease risk of injury.

1.6 SIGNIFICANT OF THE STUDY

Biomechanical loading on double instep kick with or without knee pad for Malaysian footballer that will seek for optimal variables is essential where it may contribute to succeed instep kick performance. With this study, perhaps the application of biomechanical principles to sport can improve the understanding of movement mechanisms, assess and improve performance and provide knowledge to prevent injuries.

1.7 STRUCTURE OF REPORT

This wholly report is about biomechanical loading on double instep kick for Malaysian footballer with comparison with or without knee pad. There are five chapters in this report which are Introduction, Literature Review, Methodology, Result and Discussions and Conclusion and Recommendation that will be elaborated in this report.

Chapter 1 which is Introduction that will state on introduction of the study that is consists of objective, problem statement, significant of the study, structure of report and the conclusion. Chapter 2 will elaborate on literature review which is based on previous study that relate to biomechanics, instep kick, football games and also understanding on previous study. They also can be guidance for this study references for methodology. For Chapter 3 which is Methodology, it brief about methods that will be use in this study which is design of the experiment and anthropometric data of the subjects involved. All the equipments used in the experiment will be explained. Chapter 4 is the Result and Discussion where all the data taken had been included and analyzed then compared with the previous study. Then, for Conclusion and Recommendation, it will briefly converse on conclusion based on the results and recommendation for further research.

1.8 CONCLUSION

As conclusion, this study is relate to biomechanics in football games where it is the study of instep kick techniques towards the player and comparison of using knee pad or without knee pad while kicking. Further details were explained in other chapters in this study where they were Literature Review, Methodology, Result and Discussions and lastly Conclusion and Recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will elaborate more on the understanding of the title of the study and previous study that is quite similar to it. It consists of the understanding and explanation on biomechanics and instep kick. It will also brief on quantitative analysis, factors that may contributed to a success double instep kick which based on the previous studies and reviews of previous study.

2.2 BIOMECHANICAL LOADING ON INSTEP KICK

Biomechanics is the study of living things, plant, animal, human biomechanics that investigate on human being and exercise and sports biomechanics include human that is involving in exercise and sports (Luhtanen, 1988). Biomechanical evaluations consist in measuring kinematics, kinetics and muscular activity of human movement (Cerulli G. *et al*., 2004). Kinematics analyzes the movement of the body and its parts. Kinetics is analysis of forces that produce motion while the muscular activity provides information about the action of the muscles that produce the necessary strength to create motion. The combination of these three is essential to identify functional alterations.

In addition, instep kick is the most powerful kick in football. It is known that with no limitations on the run up the instep kick is the optimal kick in terms of ball velocity (Lees, 1998) and precise (Peitersen, 1998). It is a fact that the instep kick is an open kinetic link movement that has biomechanical advantages with pre-tension in swing phase that created by run up. Basically, instep is on the top of foot where the shoelaces are tied. For performing instep kick, supporting leg is placed at the side and slightly behind the ball. The kicking leg is first taken backward swing with flexed knee. Then in following forward swing, kicking leg should be carried out in whip-like manner which is forward rotation begin with hip, followed by rotation of knee and ankle. Thigh should be slow down before ball contact and the speed of ankle and toe is increase dramatically. Timely control of kicking leg is vital for quality of instep kick (Shan G. *et al.,* 2011). An important skill in the game of soccer is the ability to kick the ball forcefully and accurately. The instep kick is the kick which is most often used for maximum force and distance, as for a shot on goal or a long pass. The force for the long kick is gained from the run-up into the ball, and from the motions of a maximum number of body parts. These include hip and trunk rotation, and hip flexion, knee extension and ankle plantar flexion to form a rigid surface for impact.

Thus, biomechanical loading in kicking for football games is important for guiding a training process. It involves the study of the different movement patterns during game and practice. The forces produce or the forces which act on a player are related to biomechanics. It indicates how this information could be applied to soccer training and coaching.

2.3 QUANTITATIVE ANALYSIS

Sports biomechanics usually will use two main approaches to analyze human movement patterns in sport which are by qualitative or quantitative analysis. As for this study, quantitative analysis will be involved. Good quantitative analysis needs a sound of grasp or movement interactions involved in a specific activity. For this analysis, analyst should decide the measurement techniques and methods to obtain the information required (Bartlett, 2007). From this analysis, biomechanical data were easy to obtain and reliability and objectivity is also easy to access. Videography is by far the most likely method of recording the movement patterns. Moreover, quantitative biomechanics analysis is mainly interested in improving performance and also reducing injury risk. Quantitative analysis will often involve analysis that digitizes a lot of data. The process of coordinate digitization involves the identification of body landmarks used to aid the estimation of joint axes of rotation. In videography method, which is particularly in three dimensional studies, it will normally be done by investigator manually digitizing the required points using computer mouse or other similar device. Somehow, some video analysis system can track markers in two dimensions where it saves the investigator time. Automatic marker tracking system will track marker automatically and in three dimensions although operator intervention may still be needed if too few cameras can see the marker during some part of the movement. Whichever of the coordinate digitizing is performed, the linear coordinates of each digitized points are recorded and being stored in computer memory.

2.4 FACTORS THAT CONTRIBUTED TO A SUCCESS INSTEP KICK

Football is the world most popular sport that is played in practically every nation at varies levels of competency. It may be played for a career, for fun or for recreational activities (Reilly, 1996). It is a high performance sport that requires speed, strength, flexibility, agility and endurance. In biomechanical aspects, it is known that with no limitation on the run up the instep kick is the optimal kick in term of ball velocity (Lees, 1998) and fairly precise (Peitersen, 1998). Instep kick is an open kinetic link movement that has biomechanical advantages with pre-tension in swing phase partly created by run up. It has large area where is more precise rather than toe kick in unstressed movement (Huddleston and Huddleston, 2003).

Goodstein stated in his article that kicking primarily contracts the hip flexors, knee extensors and abductor. For a success instep soccer kick, various factors involved which are the distance of the kick from the goal, type of kick used, air resistance and technique of the main kick which best describes using biomechanical analysis (Lees, 1996). There are others factors such as training, equipment involved, injuries, role of the arm and supporting leg, conservation of linear momentum during collision, velocity of the foot, speed of the ball, accuracy of kicking, length, speed and angle involved, hip linear motion, dominant limb or preferred leg, age, position of players in the game and fatigue.

2.4.1 Training

Instep kick is the kick of choice in soccer scoring and passing over medium to long distance. Therefore, instep kick also needs training so that it will lead to a success instep kick. It success also depends on many factors include strength of muscle responsible for actions of the extremity, rate of muscle force production, synchronization and energy transfer between lower extremity segments (Plagenhoef, 1971; Manolopoulus E. *et al.*, 2004).

2.4.2 Equipment Involved

In football games, the equipment involved play big roles where be the major effect on the way of the game is being played. The characteristics of the ball, surface of its ground, boot and shin guard might affect the games. Shoe construction plays a critical role in the comfort as well as function of shoe (Flores M *et al.*, 2004). It impact forces on the tissues and joints of lower body and therefore influence injury. Forefoot probably represents the part of body which has to bear the highest mechanical stress (Kleindienst F.I *et al.*, 2004; Moller, 1982). Therefore, sport shoe manufacturing so that player feel comfortable while playing soccer and it is important to consider the thickness of mid and outsole unit in forefoot region. The most flexible zone for shoes should be at the shoe flex centre. It may reduce the overuse injuries and enhanced comfort perception. While kicking, it is easy to have rotational movements where it is to produce high angular velocity to the foot. It affects the linear velocity of rotating foot where body height and length of different body segments is an advantageous feature for players because the linear velocity of rotating levers can be expressed as a product of the radius of rotational movement and angular velocity (Luthanen, 1988). Inversion ankle is one of most common sport related injuries.

2.4.3 Injuries of Players

Injuries can lead to lost playing time and an unsuccessful instep kick. It will also increase pressure on athlete trainers to reduce risk of injury to athlete. Taping is one common and widely used external support device where it can mechanically restrict the ankle from reaching the excessive inversion range of motion that can cause injury to ligament fibers and surrounding structures. It can also slow down the movement time for the ankle to reach full inversion, thereby allowing the body additional time to employ its built in protective mechanisms to decrease the risk of inversion ankle injury. As this is study about knee pad, it is quite similar function to the knee itself. Keeping the tape, adding tape and re-taping an ankle after 30 minutes exercise are equally effective in limiting amount and rate of inversion in healthy ankle (Woelfel *et al*., 2004). Knee pad can actually reduce occurrence of injuries such as pain in front of kneecap. Valgus moment acting on the knee was often high enough to cause anterior cruciate ligament (ACL) injury (Bogert A.J, 2004). Torn knee ligaments are also one of those debilitating injuries that usually hit young athletes. ACL connects the thigh bone to shin bone. Soccer is one of the riskiest sports that involve sudden stop and changes in direction and jumps that lead to ACL. It can be a big consequence where surgeons usually remove torn ligaments with tendon from another part of patient's body or cadaver and take monthly to recover (Hobson K., 2011). ACL can be ruptured via contact and non-contact mechanisms such as deceleration or sudden directional change on planted foot because of hyperextension. It is usually happen at front or side of the knee. Five components that is important to avoid the injury is by practicing perfect techniques, proper postural control, knee position is balance, neuromuscular where is able to fine tune the body's position sense, reaction timing and muscular patterning and can develop appropriate strength for specific muscle group.

2.4.4 Role of Arm and Supporting Leg

To maintain the balance of the body, the role of the arms in kicking is important. They usually extended out to the sides of the body during the forward motion of the kicking leg to help to keep the center of gravity over the support foot and increase the moment of inertia of the trunk and increase resistance to rotation around the spine or the long axis of the body. As the kicking foot contacts the ball, the opposite arm moves forward and upward across the body to help keep the trunk down and the body in balance. The momentum of the kicking foot and leg is the product of the mass of the leg and the velocity of the foot at impact and also the velocity of the body as the player approaches the ball. It can be said that the greater the mass of the leg and the greater the velocity of the foot at impact, the greater the resultant velocity of the ball at impact. The placement of supporting foot also gives an impact.

2.4.5 Conservation of the Linear Momentum in Collision

From the point of view of biomechanical principles in kicking the ball, the velocity production of the ball can be evaluated according to the conservation of the linear momentum in collision. The action of the ankle can increase the release velocity of the ball a little. Through elastic collision, linear momentum transfers partly to the ball. The bigger is the leg mass the higher the ball velocity. The point of application must be inside the effective hitting area, which depends on the tension in the ankle. The acceleration of the kicking leg and the resultant velocity at impact is determined by the muscle forces being applied by the kicker. It has been reported that the speed of the ball at impact was directly related to the measured strength of his subjects. The release velocity of the ball with respect to timing had the strongest relationship to the maximal torque produced during the hip flexion, knee extension and short ankle stabilizing in the kicking leg. Also the relationship between the maximal resultant forces of the thigh and shank and the release velocity of the ball was strong. The relationship between the release velocity of the ball and age was high but less than with weight or height. Thus the increase of the body mass means increase in the mass of the foot and this automatically increases the release velocity of the ball in the kick. The player can also influence the effective mass of the foot by instantaneously changing muscle tension in the muscles around the ankle. The regulation of the effective mass in the kicking foot might play an important role for getting the high release velocity to the ball (Luthanen 1988).

2.4.6 Velocity of the Foot

There are many practical ways to increase the release velocity of the ball. Kicker can only affect the ball while the kicking foot touches the ball. The behavior of the ball is decided by positional relation between kicking foot and the ball and moving direction and velocity of kicking foot (Ozaki and Aoki, 2007). Higher release velocity of the ball can be reached by increasing the velocity of the foot mechanically for the contact phase with foot and ball which by leaning the body away from the ball and balancing the body with extended arms during the kicking movement. The moment arm is defined as the perpendicular distance from the axis of rotation; usually through a body joint to the center of gravity of the resistance, in this case the ball. The greater the distance from the center of the ball to the center of the active joints in the kick, the longer the lever system acting, the faster the speed of the kick. By fully extending the leg at impact, and leaning away from the ball, the kicker will increase the speed at the end of the foot (Luthanen 1988). Skilled kicker is seen to lean sideways away from the ball during swing of the leg and through impact with the ball. The trunk is seen to lean towards the non kicking side. By leaning away from the ball, this lifts the kicking hip upward relative to the ground and helps clear the toes of kicking foot and also prevents them touching the ground. Since the ankle is maximally extended in instep kick, the hip must be raised to allow the foot point downwards during kicking. Moreover, the lean body also allows a wider swing of kicking leg and increase the length of moment arm for rotation around left hip. The placement of support foot behind and beside the ball is essential. There is no general consensus regarding the placement of ball beside the foot. It has been suggested that the foot should land 5-10 cm behind and 5-28 cm beside the ball (Hay, 1993). This is not confirmed experimentally. Thus, further investigation is necessary to examine optimum distance for placement of supporting leg. The higher the ball speed with preferred leg, the higher the foot speed and the higher the coefficient of restitution (Dorge H.C. *et al.*, 2002). Velocity of foot is a function of linear velocity of knee and angular velocity of shank. Previous study had use angular velocity of shank as measure of success of a kick (Luhtanen, 1988). It is important to achieve high ball speed in soccer since it gives goalkeeper less time to react, thus improving one chances of scoring.

2.4.7 Speed of the Ball

The speed of ball is also the main biomechanical indicator of kicking success and the results of various factors, including technique (Lees and Nolan, 1998), optimum transfer of energy between segments (Plagenhoef,1971), approach speed angle (Isokawa and Lees, 1998; Kellis *et al*., 2004), skill level (Commeti *et al*., 2001; Luhtanen, 1988), gender (Barfield *et al.,* 2002), age (Ekblom,1986; Narici *et al.,* 1988), limb dominance (Barfield,1995; Barfield *et al*., 2002; Dorge *et al*., 2002; Narici *et al.,* 1988; Nunome *et al.,* 2006), maturity (Lees and Nolan, 1998), the characteristics of foot-ball impact (Asai *et al*., 2002; Bull-Andersen *et al.,* 1999, muscle strength and power of the players (Cabri *et al.,* 1988; De Proft *et al*., 1988; Dutta and Subramanium, 2002; Manolopoulos *et al*., 2006, and type of kick (Kermond and Konz, 1978; Nunome *et al*., 2002). Ball speed values during competition and the one under laboratory conditions are reported slightly different where during the competition; it is much higher (Ekblom, 1994). The reasons are still unclear where it is maybe due to the training level or nature competition itself.

2.4.8 Accuracy of Kicking

Accuracy of kicking is having less attention rather than powerful kick. It can be examined by recording angle between the direction of kicking and desired direction (Wesson, 2002). Kicking accuracy is depends on how fast the player approaches the ball (Godik *et al*., 1993). Research found that when there are instruction to the player to perform instep kick at their own speed of approach, then the faster kicks are the most accurate ones while if they are instructed to kick the ball as maximally as possible, then the higher the run up speed the less accurate the kick. Therefore, it can be said that there is an optimal approach speed in order to achieve an accurate kick (Godik *et al.,* 1993). Teixera *et al.,* (1999) found that kicking towards a define target have longer duration and smaller velocity and ankle displacement compared with kicks performed towards an undefined target. Thus, it shows that the target determined the actual constraints on accuracy; its manipulation leads to a tradeoff between speed and accuracy of the kick. It also can be said that when the player is instructed to perform an accurate kick, then the velocities are lower compared to those recorded during powerful kick. Another point that can make inaccuracy occur is the error in the force that applied to the foot (Asai *et al.,* 2002; Wesson, 2002). The first is arises from the error in the direction of applied force and second is due to the misplacement of force. If the ball is being hit at its center, it will follow a near straight trajectory and gain maximum possible velocity with minimal spin (Asai *et al*., 2002). The ball demonstrates higher forward velocity compared with foot velocity, where depending on the coefficient of restitution (Wesson, 2002). In contrast, if the force applied to the ball is directed at an angle relative to the desired direction, then the ball will have lower speed, a higher spin and a longer and more curved path with possible change in final direction of the ball (Asai *et al*., 2002; Wesson, 2002). Both techniques can give an accurate kick. It is also depends on position of the ball relative to the goal and external conditions such as air resistance and opponents. As in currents game shows that long distance kick or free kicks as an example are characterized by curved and longer ball path and spin where as kicks that performed within the penalty area or short distance kicks generally faster as player should hit the ball as fast as they can in order to surprise the goalkeeper. Thus, the point of contact between foot and ball is depends on the aim and external conditions.

2.4.9 The Length, Speed and Angle Approach

The length, speed and angle approach are the most important aspects in football movement which give significant effect on football kick success (Isokawa and Lees, 1988; Kellis *et al.*, 2004; Opavsky, 1988). Kicking from an approach angle of 45° to 60° may alter aspects of technique, such as enhancing pelvic rotation, and thigh abduction of kicking leg at impact which is better ball contact and may increase ball speed (Lees and Nolan, 1998; Barfield, 1998; Scurr and Hall, 2009). Kicking with running approach demonstrates higher ball speed values compared with static approach kicks (Opavsky, 1988). Applying third step run also create better distance, higher maximum velocity and higher maximum force resultant (Ismail A.R *et al.*, 2010). A game usually shows that football players prefer multi step approach where more often two or three steps prior to main kicking action. Furthermore, in most cases, football kick is not performed against a stationary ball, but the ball is rolling to the player.

2.4.10 Hip Linear Motion

Hip linear motion give impact on lower leg angular velocity during soccer instep kicking. Knee extension motion typically observed for support leg likely links to upward lift of hip, where it is an effective action of the interactive moment to be induced (Nunome *et al.*, 2005). During final phase of kicking, the upward hip lift that plays a subtantial role in increasing the lower leg angular velocity.

2.4.11 Age

Previous studies had reported that maximum ball speed and knee angular velocity increase with age (Luhtanen, 1988). Ball speed is increases with age due to the increased of muscle mass and technique improvements (Poulmedis *et al.*, 1988; Rodano and Tavana, 1993; Taina *et al.,* 1993). Improvement in kicking performance is actually because of the higher levels of muscle strength of players, which due to maturation and growth. Research had shown that females have the ability to instep kick on dominant and non-dominant sides with similar kinematics characteristics as men (Barfield *et al.,* 2002). However, females generally demonstrated less ball velocity than their male counterparts (Barfield *et al.,* 2002). It is due to lower foot and ankle speed in females compared with males. Knee extension velocity of female when kicking is higher with dominant leg compared to males.

2.4.12 Dominant and Non-Dominant Limb

Higher ball speed values are shown when players kick the ball with dominant limb as opposed to kicks with the non-dominant leg (Nunome *et al.*, 2006). This was attributed to higher moment which produced by dominant limb compared to non-dominant limb and a better inter-segmental pattern and a transfer of velocity from foot to the ball when kicking is done with preferred leg (Dorge *et al.,* 2002). Differences between two limbs is depends on the skill of the player (Nunome *et al.,* 2006). The higher the skill level, the better the coordination for both limbs (Nunome *et al.*, 2006). Higher muscle loading was found in kicking leg (Scurr and collegues, 2009). Kick to the right target produced greater muscle activity than those towards left target while kicking to top right corner of goal demonstrate the highest quadriceps EMG level than those towards left corner. So, it is suggested that top right instep kick would be the best most powerful kick for accelerating ball.

2.4.13 Position of the Players

Position in soccer games also plays an important role. Midfielders can perform strong and faster than defenders and there is however no significance different between midfielders and strikers but midfielders' ball velocity is higher than strikers ball velocity (Khorasani, 2009). This is due to midfielders that cover greater total of distance than any other players in other positions in the games. Previous research by Reilly and Thomas (1976) had found that midfield players covered the greatest distance which is 9805 m during a game, as well as more distance sprinting than either centre backs or full-backs. Defender covered less total distance and also perform less high intensity running than players in other positions (Bangsbo, 1994) whereas strikers covered distance at high intensity equal to full back and midfield but performed more sprints than midfields and defenders (Mohr *et al.*, 2003). As for Khorasani (2009) research, it can be said that soccer midfields and strikers perform instep kick faster than defender based on biomechanical characteristics. Strikers perform faster than defender and midfields have highest individual value in ball velocity due to high velocity and do more forward movement than other position during training and competition. Furthermore, midfield have experience in kicking ball at an approach angle of 0° and due to psychological perspective, their minds were ready for this skill more than other players.

2.4.14 Fatigue

Fatigue is defined as failure to maintain the required or expected power output (Edward, 1983). Fatigue or reduced performance seems to occur at three different stages in soccer games. First is after short term intense period in both halves, second is in initial phase of second half and the last one is towards the end of the game. In initial phase of second half, players inhibited due to lower muscle temperature compare to the end of first half. Thus, when players perform low intensity activity in internal between two halves, both muscle temperature and performance are preserved. At the end of the game, fatigue occur due to low glycogen concentration in considerable number of individual muscle fibers (Mohr *et al.*, 2005). It can be proved when amount of sprinting, high intensity running and distance covered are lower in second half than in the first half of game (Bangsbo, 1994, 2006; Mohr *et al.*, 2003). However the fatigues that occur in the game sometimes are temporary. After the intense period in first half, the players' sprint performance was reduced whereas at the end of first half the ability to perform repeated sprints was recovered (Figure 1.1). Based on Mohr *et al.*, (2003) for both top class and professional players of lower standard, the amount of high intensity running was reduced in the last 15 minutes of the games. One type of fatigue is muscle fatigue. It was induced by repeated knee extension and flexion until exhaustion (Aprianto T, 2004). Ball speed will reduced in fatigue condition and also decreased the leg swing speed that represented as toe linear velocity at ball impact and peak shank velocity. Muscle fatigue significantly decreased the magnitude of muscle moment for knee extension during kicking. It leads to worse inter-segmental coordination during kicking.

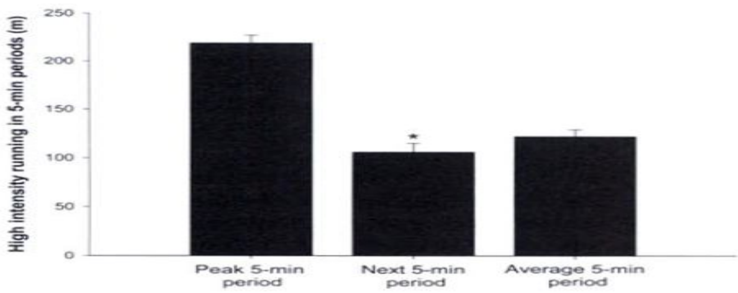


Figure 1.1: High intensity running in 5-min period during game, the following 5-min period as well as the game average for elite players during competitive matches.

Source: Mohr *et al.* (2003)

Previous study focuses on ball velocity as an indication of success in instep kick. As we know, instep kick have three phases which are swing, ball contact and follow through. There is one study on knee flexion in four different targets by Ayhan Goktepe (2008) that found that there is no significance knee flexion differs when kicking to upper left, upper right, lower left and lower right target during that three phases. They all have similar knee flexion. However there is some difference at ankle through ball contact and follow through phase when lower right and lower left were targeted.

2.5 REVIEWS ON PREVIOUS BIOMECHANICAL STUDY

There is lots of previous research study that is related to biomechanics study and football games have been published within the last decades which are based on several factors. All of them may help in this study as a guidance and references for a better methodology and results.

2.5.1 Kinematic Analysis on Number of Trials for Soccer Instep Kick

This study is to investigate the stability of kinematics responses that is relates to stretch shortening cycle (SSC) during ten consecutive soccer instep kick. As stated in this study, too few numbers of trials may not represent individual’s long term performance. The main findings of this study were significant increases in eccentric angular velocity after the sixth kick, significant decreasing in concentric angular velocity after the fifth kick, significant increasing in duration of eccentric after the fourth kick and significant rise in duration of concentric after the fifth kick. Decreasing of velocity during those ten consecutive kicks may due to effects of fatigue on leg extensors where it is the main force of producing muscle group by SSC. Eccentric contraction produces more force than concentric contraction because of the fatigue that occurs earlier in concentric contraction than eccentric contraction. Khorasani *et al*. (2010) concluded that five consecutive kicks is already adequate to achieve high kinematic responses related to SSC. Five kicks trials are already enough as it is optimal for players to perform well coordinated segmental pattern for final analysis. It is due to high level of force production of SSC during the first five kicks compared to the second five kicks. It is suggested to the coaches or trainers to design and conducts training sessions for players with not more than five consecutive soccer instep kicks.

2.5.2 Biomechanics of Instep Kick Between Different Positions

This study investigates on some of biomechanics characteristics of lower extremity between professional soccer defender, striker and midfielders. In this study, it concludes that midfielders perform soccer instep kick strongly and faster than defenders and there is no significance difference between midfielders and strikers but midfielders' ball velocity is higher than strikers' ball velocity. The results is might due to the midfielder that often do forward movement than the other position during training and competition, (Khorasani, 2011). A method that is used in this study is limited to the subjects to run forward at an approach angle of 0°. It is also maybe due to midfielders that can perform it at high level with faster kick and good results. Midfielders usually cover great total of distances than striker and defender and can perform both offensive and defensive skill with long run and it shows that midfielders have high level of aerobic fitness. It seems that midfielders also have more economy motion to save energy and perform higher intensity task. In Khorasani and colleagues findings, midfielders perform great value of moment in lower leg during leg extension. Therefore, they concluded that midfielders successes for instep kicking which is run forward to kick the ball rather than other position.

2.5.3 Biomechanics Analysis and Optimization of Instep Kicking

Biomechanical analysis has been used to identify variable such as velocity, acceleration, distance and angle of knee to see whether it affects Malaysian footballer kicking force (Ismail A.R., 2010). Data collected and analysis in this study used Silicon Pro Coach software while statistical analysis used Minitab's software. The variables were identified to be significant to the force model besides succeeded to obtain the force equation model. In this study, optimum kicking value is got from Taguchi's method. Taguchi method is one of the methods that complementing system methodology for efficient optimum design. It is totally based on statistical design of experiment and can economically satisfy the needs of the problem solving and product or process design optimization. A concept of S/N ration is used where it is useful in improvement of quality through variability reduction and improvement of measurement. There are three categories for S/N ratio characteristics when the characteristics are continuous as indicated in Equation (2.1), Equation (2.2) and Equation (2.3).

a) Larger is better characteristic

$$\textbf{MSD} = [1/Y_1{}^2 + 1/Y_2{}^2 + 1/Y_3{}^2 + \ldots] / n \qquad (2.1)$$

b) Nominal is best characteristics

$$\textbf{MSD} = [(Y_1 - Y_0)^2 + (Y_2 - Y_0)^2 + (Y_3 - Y_0)^2 + \ldots] / n \qquad (2.2)$$

c) Smaller is better

$$\textbf{MSD} = [Y_1{}^2 + Y_2{}^2 + Y_3{}^2 + \ldots] / n \qquad (2.3)$$

Where:

1) Y_1, Y_2, Y_3,….Y_n is decision value something experiment
2) n is value number
3) Y_0 is target value

As to analyze the level of ability decision on velocity and distance, larger is better being chosen to this study. It is due to possibilities to get maximum distance and velocity in ankle contributing to maximum force. For the methodology of this study, the subjects is required to make kicking without running and only use one step run, two step run and three step run in three times trial. Thus, the result of this study shown the highest average forces produces in force model analysis gained using three step run. The highest average force in right leg analysis is 5879.60 N and highest average velocity is 8.2 m/s with kicking distance achieved up to 47.85 m. as from this study, which is using the Taguchi's method, Ismail and colleagues found that the highest optimum force achieved from three step run is 0.163 m for optimum distance and 8.035 m/s for optimum velocity where the optimal force equal to 5602.12 N.

2.5.4 The Effect of Hip Linear Motion on Lower Leg Angular Velocity

This study investigates the influence of hip linear motion on the lower leg kinematics for soccer instep kicking. The moment due to hip linear acceleration, (MHLA) exhibit a large positive moment to increase lower leg angular velocity during final phase of kicking. It is usually due to upward acceleration of the hip and also most likely due to support leg motion such as knee extension motion during kicking (Nunome, 2005). A digitizing system was used to manually digitize body landmarks which include right hip, right knee, right ankle, right heel, and right toe since the subjects will perform kicking with right leg. Centre of the ball also digitized in initial stationary position and in all available frame after it left the foot. The direct linear transformation (DLT) method was chosen to obtain three dimensional coordinate for each landmark. From Nunome and colleagues study, they used procedure of Putnam (1991) where interactive MHLA was computed from two link kinetic chains composed of thigh and lower leg as indicated in Equation (2.4).

$$\mathbf{MHLA} = r_L \times (m_L \cdot a_{hip}) \qquad (2.4)$$

Where:

1) r_L is vector from lower leg CG to knee joint centre.
2) m_L is mass of the lower leg
3) a_{hip} is hip linear acceleration vector

The finding from this study was the interactive moment is occur during the final phase of kicking is mainly caused by upward hip lift that plays a substantial role to increase lower leg angular velocity. The effective action the moment due to the upward hip lift is most likely due to support leg motion such as knee extension during kicking.

2.5.5 Effect of Leg Muscle Fatigue on Instep Soccer Kick

Apriantono *et al.* (2004) examined the effects of muscle fatigue on soccer instep kicking motion. The muscle fatigue may occur due to repeated knee extension and flexion until exhaustion. From the findings, Apriantono and colleagues found that the muscle fatigue declined the peak linear and angular velocity of the distal segment during kicking. It was attributed to the reduced peak magnitude of resultant moment and motion depended interactive moment acting at knee joint. Thus, the result of this study showed that due to fatigue condition, the average isokinetic peak torques for knee extension and flexion in all velocity conditions is reduced. The initial ball velocities of all participants were consistently and significantly decreased after muscle fatigue was induced. In addition, the peak shank angular velocity and toe linear velocity at ball impact were also decrease while there is no differences in were observed for the peak thigh angular velocity. Therefore, it can be considered that the reduced ball speeds in fatigue condition was due to decreased leg swing represented as toe linear velocity at ball impact and peak shank angular velocity. The muscle fatigue significantly decreased the magnitude of muscle moment for knee extension during kicking. Leg muscle fatigue not only declined the muscle moment but also lead to worse inter segmental during kicking.

2.5.6 Foot to Ball Interaction in Preferred and Non Preferred Leg

This study by Smith *et al.* (2004) compared the characteristics of foot to ball interaction between preferred and non preferred kicking leg in Australian Rules Football (ARF). Calculation and analysis is done to seven parameters that are identified as essential during foot to ball impact (Table 2.1).

Table 2.1: Definition and calculation of measured parameters

Parameter	Definition
Foot speed (ms^{-1})	Foot speed was defined as the average speed of the centre of the foot prior to initial foot-ball impact. X and Y coordinates of four points on the kick leg (ankle, heel, head of fifth metatarsal, toe of boot) were averaged to approximated the centre of the foot. Foot speed was calculated in X and Y directions between each frame, and then averaged across all the digitized frames prior to initial foot-ball impact. The resultant foot speed was then calculated using quadrature summation.
Ball speed (ms^{-1})	Ball speed was defined as the average speed of the centre of the ball across all ten digitized frames after release. X and Y coordinates of two points (bottom of ball, top of ball) used to approximate the center of the ball. Ball speed was calculated in X and Y directions between each frame and then averaged across all the digitized frames after foot-ball release. The resultant ball speed was then calculated using quadrature summation.
Ball : foot speed ratio	Ball: foot speed ratio was defined as the average ball speed at release divided by average foot speed at initial impact.
Time in contact (ms^{-1})	Period of contact between foot and ball from initial impact to release. Time in contact was calculated using the timer function supplied by Silicon Coach. The timer function was used to determine the number of frames in which the foot was in contact with the ball. Once the number of frames was determined, this was then divided by the frame rate (6000 Hz) to give time in contact between foot and ball.

Source: Smith *et al*. (2004)

Table 2.1: Continued

Parameter	Definition
Ball displacement (m)	Ball displacement defined as the change in displacement between the centre of the ball at initial impact and the center of ball at release. The X and Y coordinates of the two points on the ball (bottom of ball, top of ball) were averaged to determine the position of the center of the ball. Ball displacement was then calculated by subtracting the coordinates of the center of the ball at impact from the coordinates of the center of the ball at release.
Change in shank angle (°)	Difference in shank angle (angle between the horizontal axis and line between the head of fibula and ankle of the kick leg) between initial impact and release. The horizontal angle function supplied by Silicon Coach was used to find the shank angle by digitizing the head of fibula and ankle. Shank angle at impact was then subtracted from the shank angle at release to determine change in shank angle.
Work done on the ball (J)	Calculated using the formula, Work = Mass x Acceleration x Displacement. Approximated using the mass of the ball at 450 g, ball acceleration during foot-ball impact (calculated from change in ball speed during foot-ball impact divided by time in contact) and ball displacement. Change in ball speed (used in ball acceleration) was defined as the difference between average ball speed before impact and average ball speed after release.

Source: Smith *et al*. (2004)

The findings showed that preferred and non preferred leg differed significantly for five of the seven parameters analyzed. In all cases, preferred leg kicks produced the greater values with a large effect size. No significant difference existed between kicking legs for ball: foot speed ratio and time in contact although for both, a small effect existed. Thus, preferred foot kicks produced greater foot and ball speed, ball displacement, change in shank angle and work done to the ball (Smith *et al.,* 2004).

2.5.7 Run up Deceleration

The purpose of this study is to investigate if the momentum transfer to leg segments due to the deceleration of the run up velocity of the center of mass could influence ball speed. The results of the study showed that the intensive deceleration of the run up within the last step of the stance leg is correlated (r=0.6) to higher ball speed (Potthast, 2010). In addition, kicks with the highest ball speed coincide with high center of mass deceleration and high increases of angular impulses of the thigh. As for the other side, the slower kicks coincide with smaller center if mass deceleration and smaller changes of thigh angular impulses. High angular impulse of thigh can be beneficial for fast instep kick.

2.5.8 Kinematic Analysis of Instep Penalty Kick

This study was conducted to four different targets placed at upper left, upper right, lower left and lower right corners in the goal. Instep kick can be divided into three phases. They are swing, ball contact and follow through. Each phase should be able to execute enough to kick the ball to desired location. The swing, ball contact and follow through were analyzed using dual camera and Pictran software system. Results revealed that subjects significantly had higher ankle extension while hitting the target at upper right (m= 77.6 degree, sd= 10.5) and lower right (m=84.4 degree, sd= 10.1) corners. It concluded by Goktepe *et al.*, (2008) that players presented similar knee flexion but not ankle extension kinematic strategies at the contact and follow through phases of instep penalty kick to different corners in the goal. Players tend to use similar knee flexion strategy to four different targets.

2.5.9 Lower Extremity Muscle and Alignment during Soccer Instep and Side Foot Kick

Soccer players faced high risk of lower extremity injury which usually knee injuries. Kicking is the essential part of soccer player activity that also plays a role in soccer player injury. Moreover, regaining the ability to kick is also important for soccer athletes to return to play in games after injury (Brophy, 2007). The objectives of this study is to quantify phase duration and lower extremity muscle activation and alignment during the most common types of soccer kick which are instep kick and side foot kick. It was also to test the hypotheses that different pattern of lower extremity muscle activation occur between the two types of kicks and between the kicking limbs compared to support limb. Two main techniques of kicking is side foot kick which strikes the ball with medial aspect of midfoot and instep kick which strikes the ball with the dorsum of foot. Both of the techniques can deliver power and accuracy of kicking by the player. There are five phases of kicking motion defined by six events (Figure 2.1 and 2.2). They are preparation, backswing, leg cocking, acceleration and follow through.

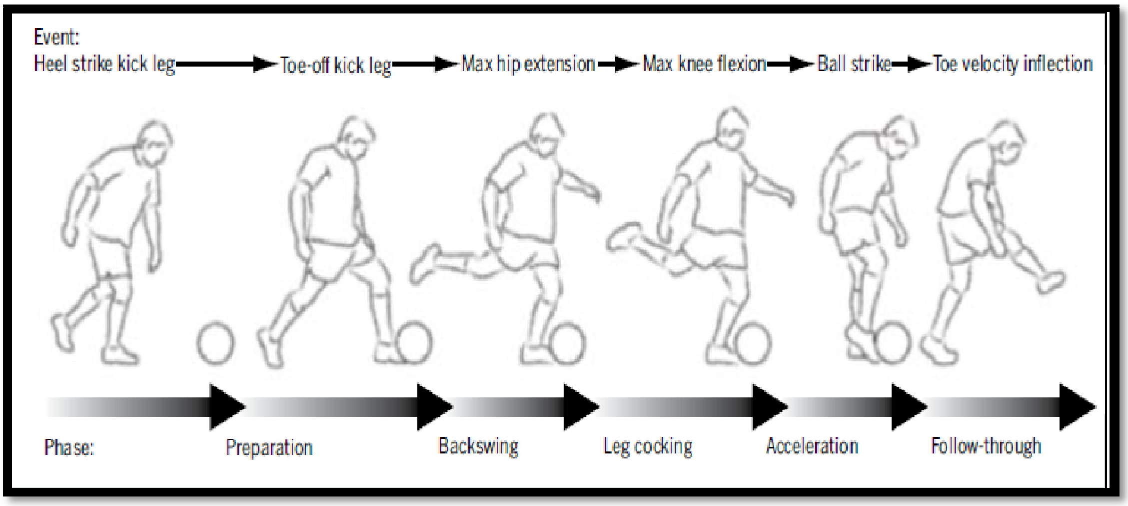


Figure 2.1: The instep kick is divided into five phases delimited by six events

Source: Brophy (2007)

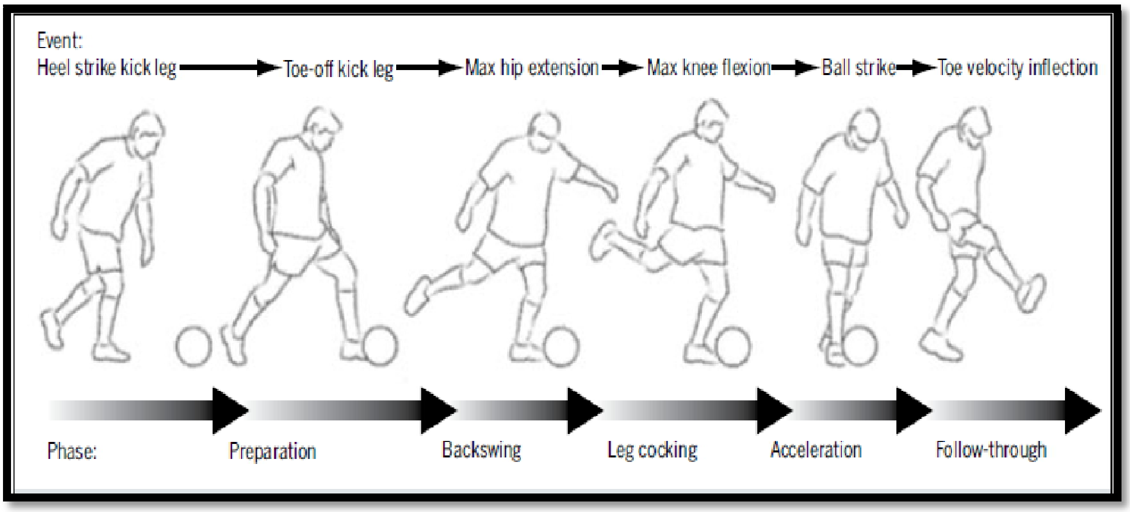


Figure 2.2: The side-foot kick is divided into five phases delimited by six events

Source: Brophy (2007)

For the findings of this study, the average length of time in kicking motion was 0.79 seconds for instep kick while for the side foot kick was 0.83 seconds (Table 2.2). The mean duration of each phase and percent of total kicking time for each kick was stated. As been shown from the findings, the longest phase of kicking was phase five which is the follow through. Therefore, limb cocking and acceleration were a relatively small proportion of the kicking motion for both types of kicks. There was no statistically significant difference between these two kicks in term of actual time or percent of kick spent in each phase.

Table 2.2: Phases of kicking

Phase†	Instep Kick	Side-foot Kick
1. Preparation	0.18 ± 0.06 (22.3%)	0.19 ± 0.07 (23.4%)
2. Backswing	0.16 ± 0.02 (20.5%)	0.14 ± 0.03 (17.3%)
3. Cocking	0.04 ± 0.01 (5.2%)	0.05 ± 0.02 (6.5%)
4. Acceleration	0.06 ± 0.03 (7.3%)	0.04 ± 0.02 (4.8%)
5. Follow-through	0.35 ± 0.11 (44.7%)	0.40 ± 0.16 (48.0%)
Total	0.79 ± 0.12 (100.0%)	0.83 ± 0.20 (100.0%)

**Data expressed in mean ± SD seconds and percent of total kicking time.*
†No significant difference for the duration of each phase between kicks (P>.05).

Source: Brophy (2007)

The mean ± SD ball marker velocity for instep kick was 17.1± 4.3 m/s while the mean ± SD ball marker velocity for side-foot kick was 16.1±2.3 m/s (P>0.05). For lower extremity alignment data (Table 2.3), the only significance difference was greater hip extension with the instep kick (P=0.02).

Table 2.3: Lower extremity alignment data

	Instep Kick	Side-foot Kick
Kicking limb		
Maximum knee flexion	82.4° ± 10.5°	84.0° ± 6.2°
Maximum hip extension†	9.3° ± 6.6°	5.1° ± 7.3°
Supporting limb knee		
Maximum varus (+)/valgus (−)	4.8° ± 6.8°	5.1° ± 5.7°

**Data expressed as mean ± SD.*
†Significant difference between type of kick (P = .02).

Source: Brophy (2007)

The results of this study is quite differed with the previously published study where it showed a longer back swing phase but shorter cocking phase (Brophy, 2007). Thus, soccer instep and side-foot kick occur with measurable phase timing and muscle activation by electromyography (EMG). The different muscle can be grouped according to their activation pattern in a manner that appears logical. Certain lower extremity muscle groups face different demands during the soccer instep kick compared to side-foot kick. Similarly, the support limb muscle faces different demands than the kicking limb during both kicks. Better definition of lower extremity function during kicking provides a basis for improved insight into soccer player performance, injury prevention and rehabilitation.

2.5.10 Kinematic Comparison of Successful and Unsuccessful Instep Kick

Instep kick is often used when tacking a penalty kicks as a combination of increased ball speed and kick accuracy can be maintained. The purpose of this research which had been done by Gheidi *et al*. (2010) was to compare selected kinematics parameter of the kicking foot during the performance of successful and unsuccessful penalty kick from 6m distance. The kinematic parameters were compared by using independent t- test. The level of significance was set to $\alpha = 0.05$. This research was conducted by using subject of male and female elite players. The subjects were asked to perform instep kick starting with one step angled approach of 45° to a stationary indoor soccer ball which is the best angle for approaching (Scurr and Hall, 2009). For this study, any kick that hit the target was assumed as successful kick and vice versa. The kinematic variables that involved are linear velocity of toes, ankle, knee, hip, the angle of ankle, knee, hip joints, and angular velocity of the thigh and shank that were measured. The result of analysis showed that successful kicks had lower linear velocity than the unsuccessful kicks but for women's group, the maximum linear velocity of the ankle and knee and the average linear velocity priors to the kick in successful kick were lower than unsuccessful kicks but the average linear speed of women's ankle and toes after the kicks in successful kicks was more than unsuccessful kicks. However, the difference was not statistically significant. For male's group, there was a significance difference where in between the velocity of ankle and toe at ball impact, the maximum speed and average linear velocity after the kick in successful and unsuccessful kicks. This study also showed the importance of follow through phase in executing of an accurate kick. If the follow through phase is performed with faster speed, the ball is also sent with higher speed and also there is a possibility of decrease in precision. It can also decrease the risk of injury of the kicking leg.

2.5.11 Biomechanical Differences in Soccer Kicking With the Preferred and Non-Preferred Leg

The aims of this study by Dorge *et al.*, (2001) were to examine the release speed of the ball in maximal instep kicking with preferred and non preferred leg and also to relate ball speed to biomechanical differences observed during the kicking action. As in this study, higher ball speed were achieved with preferred leg as a result of higher foot speed and coefficient of restitution at the time impact compared to non preferred leg. Higher foot speed was caused by the greater amount of work on shank originating from angular velocity of thigh. Thus, the difference in maximal ball speed between the preferred leg and non preferred leg is caused by a better inter-segmental motion pattern and a transfer of velocity from foot to ball when kicking with preferred leg. The ball speed of soccer kicks depend on speed of foot before impact and mechanics of the collision between the foot and the ball (Dorge *et al.*, 2001). The differences of coefficient of restitution in this study must have been due to the mechanical properties of foot and ankle joints at impact. Small difference in extension and stiffness of these joints would probably alter the mechanics of collision, and cause the coefficient of restitution to differ.

2.5.12 Effect of Training Programs during Instep Kick

This study was to examine the effect of soccer which is based on strength and techniques in training programs on kinematics and EMG muscle activity during instep kick. The main findings of this study is that a combined strength and kicking coordination training programs applied resulted in significant increase in ball speed and some kinematic parameters of soccer kicks whereas performance in maximum strength, cycling speed and ten meter sprint test also improved. Training caused a significant increased in ball speed where it shows it improves soccer kick performance (Manolopoulus *et al*., 2006).

2.5.13 Isokinetic Strength and Anaerobic Power of Elite, Sub elite and Amateur Soccer Players

This study accessed muscular strength and anaerobic power of elite, sub elite and amateur soccer players to clarify what parameters distinguish the top players from the less successful. Thus, Cometti *et al.,* (2001) conclude and points out the differences between the three group of players. The first one was the strength of knee flexor differs between elite, sub elite and amateur players, with professional players having stronger hamstring than amateurs. The second one was a soccer player's sprint performance over ten meter is more indicative of this level of play than 30 meter sprint and the last one was the ball striking performances do not vary with the player's level. In addition, hamstring controls the running activities and stabilize the knee during turn or tackles in soccer games. It seems that the knee flexor contribution to joint stability becomes increasingly important with increasing limb velocity. It was shown in this study that elite players were significantly stronger in their knee flexor muscles than the amateur players at all angular velocities measured and the differences were greater during eccentric actions.

2.5.14 Ball Foot Interaction in Impact Phase

In soccer, ball impact technique is essential for successful in instep soccer kicking. The aims the study by Shinkai *et al*., (2007) were to illustrate the three dimensional motion of the foot and the motion of center of gravity of the ball during ball impact, and also to examine the interaction between the motion of the foot and the ball behavior during ball impact. The foot was plantar flexed, abducted and everted during the contact with the ball. In particular, the foot was dorsal flexed slightly at the beginning of impact and begin to plantar flexed after middle of the impact. Thus, in this study, it was seen that the foot was forced into plantar flexion by the force of the ball. The ball velocity was exceeded foot velocity when the ball was maximally deformed. Therefore, it can be suggested that the foot cannot directly increase the ball velocity after this moment.

2.5.15 Biomechanical Characteristics and Determinant of Instep Kick

Understanding the biomechanics of soccer kicking is particularly important for guiding and monitoring training process. This study is made to review on latest research study on biomechanics of soccer kick performance and to identify weaknesses of present research which deserve further attention later on. In soccer, angular velocity is maximized firstly by the thigh, then the shank and the last one is the foot where is accomplished by segmental and joint movements in multiple planes. During backswing phase, the thigh decelerates mainly due to motion dependent moment from the shank and to lesser extent, by activation of hip muscles. For forward acceleration of the shank, it is accomplished through knee extensor moment as well as motion dependent moment from the thigh. In addition, the final speed, path and spin of the ball largely depend on quality of foot-ball contact. In this study it stated that powerful kicks are achieved through a high foot velocity and coefficient of restitution while accurate kicks are achieved through slower kicking motion and ball speed values (Kellis *et al.*, 2007). Success of instep soccer kicks is depends on various factors including distance of the kick from the goal, type of the kick that been used, the air resistance and technique of main kick which is best described using biomechanical analysis. However, there is more research studies had been conducted within the last decade ad many aspects had been identified for improving soccer kick performance. Factors that might contribute to soccer performance such as age, gender, limb dominance and fatigue also involved (Kellis *et al*., 2007).

2.5.16 Effect of Approach Angle on Penalty Kicking Accuracy

Scurr and Hall (2009) were conducted this study to examine the effect of approach angle on kicking accuracy and three dimensional kinematics of penalty kicks. A variety of kinematic variables were chosen in this study to identify key aspects of performance. They were maximum absolute ball velocity, shank abduction angle where it is projected onto the frontal plane, anterioposterior pelvic tilt that was projected onto the sagittal plane, thigh abduction angle that was projected onto the frontal plane, ankle dorsiflexion that is projected onto sagittal plane, hip flexion, knee flexion of kicking and supporting leg, transverse pelvic rotation where is about the vertical axis and knee flexion range of motion from initiation of the kick to follow through phase. The result of this study showed that the penalty kick accuracy was not improved by altering players' approach angle. Ball velocity also remained similar between the approach conditions. With this, this study concluded that for recreational soccer players, altering an individual's self selected approach angle does not improve kicking accuracy or ball velocity during penalty kick. However, kicking from an angle of 45° and 60° may alter aspects of kicking techniques such as enhanced the pelvic rotation and thigh abduction of kicking leg at impact where it lead to a better ball contact. This result may differ for skilled players.

2.6 CONCLUSION

There were lots of researches had been done before regarding instep kick and football games as all of them had the same objective which is to improve football performance in many aspects. All of the information can be gathered as reference as well for this study.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology is essential in a study where it is guidelines for an experiment and giving information on every detail that is important in a study. It explains more on techniques or methods and equipments that is needed in a study. As for this study, the methods are quite similar and based on previous study that had been done before.

3.2 SUBJECT SELECTION

Twelve Malaysian male under 16 years old of football players were participated in this study. Their body mass, body height and age are part of data analysis. All of them have to in a healthy condition. Six players applied double instep kick with using knee pad while the other six players applied double instep kick without using knee pad. All of the subjects were executed double instep kick with one step and two step run using their preferred leg. The subjects kicked the ball using their preferred leg which is right leg and it is also considered as dominant leg. When the subject stop kicking the ball, the posture of leg from hip to knee and continue to ankle will be observe.

3.3 EXPERIMENTAL SETUP

This experiment was conducted on natural football field at National Sports Institute (ISN) Bukit Jalil while the subjects wearing their own shirts, shorts and football shoes. All the subject will go through and adequate warm up before doing the kick. They will do maximal velocity double instep kick towards a stationary ball, as it was also similar to penalty kick in football game. The subject has to hit the ball as hard as possible. The subject will be position behind the ball with an angle of 45° to do one step run and two steps run towards the ball. All of the subjects executed double instep kick with one step and two step run using their preferred leg. The ball for kicking session is a FIFA approved size 5 and mass of 435 g with pressure of 700 hpa. Markers or deflection tape will be placed laterally on kicking leg which is on lower limb for data recording of the analysis which is on their hip, knee and ankle. Two cones are setup with distance between them is fixed to one meter and the other two cones with distance of two meter (Figure 3.2). The ball is placed at the middle which is between the two cones with distance of two meter. Two high speed cameras as Figure 3.1 were used to capture lower limb when subject is kicking. High speed camera is used for a better visual. It can analyze movement as fast as 0.02 seconds per frame.

Figure 3.1: High speed camera

Posture of hip, knee and ankle is observed when subject stop kicking the ball. The subject movement will be recorded via video recording by video camera that focusing on lower limb of the subject. As in Figure 3.2, two cameras were located at the side and in front of the subject. Data for velocity, acceleration and distance involved in kicking activity can be identified (Ismail A.R. *et al.,* 2010). It will be the same with angle of hip and knee too where the y can be identify.

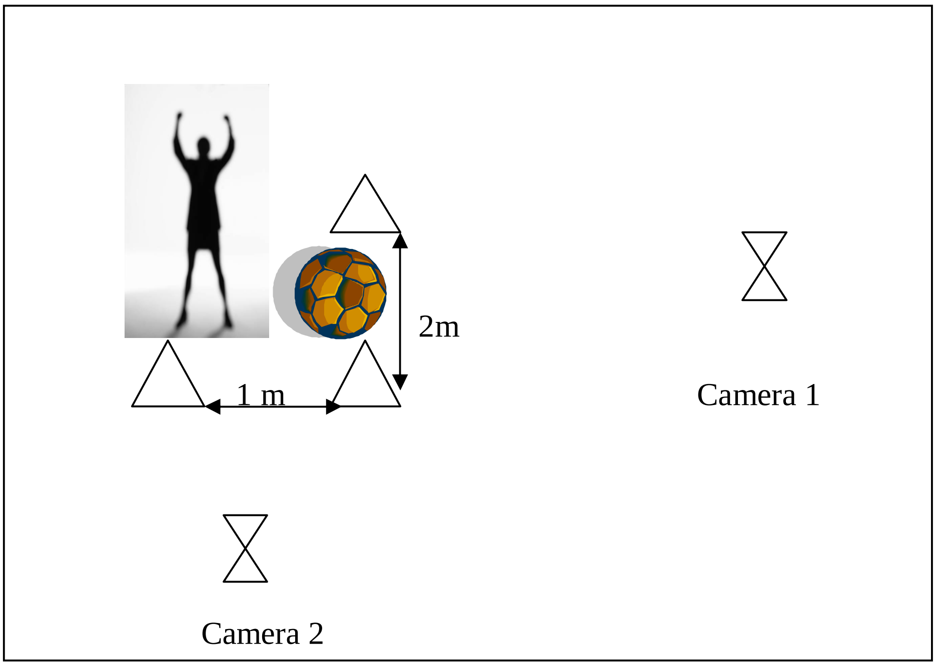


Figure 3.2: Study design

The methodology process is presented as in Figure 3.6. At first, there will be selection of the subject. All of them should be in a healthy condition and without any injuries. Questionnaire was given to all of them to fill up to know their personal details. After all criteria are being taken care of, then, there was a little warm up for the subject before performing the double instep kick. It is essential for the subject for stretching their muscle first before doing any kicking activities and also to avoid any occurrence of injury (Ismail A.R. *et al.,* 2010). Then, the study was conducted by arranging the equipment to their location that had been designed as in Figure 3.2. The kicking will now be observed and the data will be analyzed by using Silicon Coach Pro's software and Minitab software. Subjects will perform the kicking with one step and two steps run towards the ball and require repeating it three times for each kick type run step. After subject stop performing double instep kick towards the ball, the posture of lower limb will be observed. As the objectives, some of the subject needs to use knee pad while performing the kick and some does not have to.

The knee pad that the subject used in the experiment is as in Figure 3.3 and 3.4. It was Neoprene knee support (open patella). It was made of the highest grade closed cell neoprene which covered with stretch nylon on both side for the users comfort. Neoprene is the ultimate material for compression and heat retention which helps improve blood circulation. The combination provides a therapeutic treatment to muscle and joint pain or injury.

Figure 3.3: Front side of knee pad

Figure 3.4: Back side of knee pad

Figure 3.5: Experiment setup at ISN

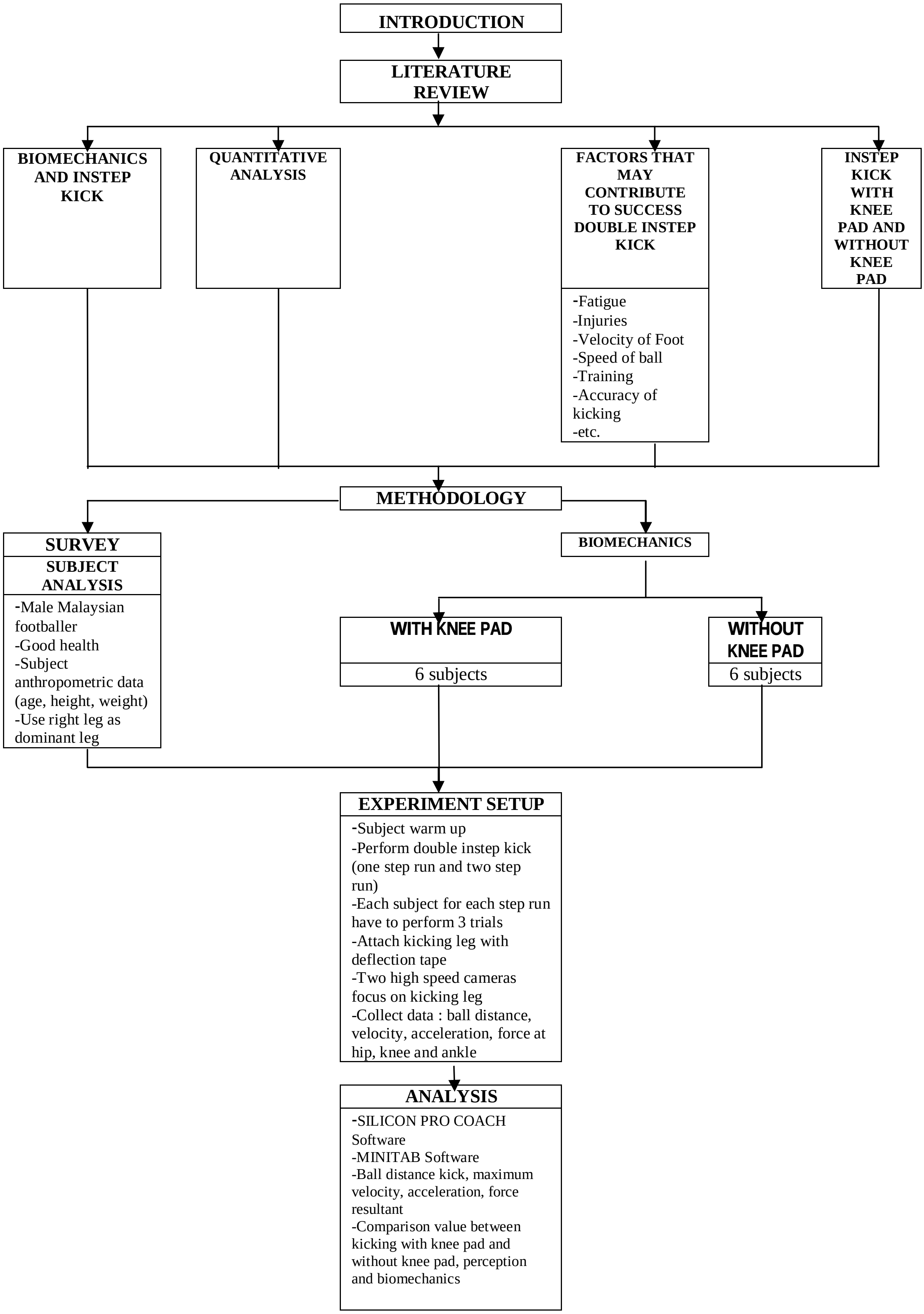


Figure 3.6: Methodology process

3.4 DATA ANALYSIS

There are three phases for kicking movement (Luhtanen, 1988). The first phase is defined from start of movement up to the contact of support leg on the ground. The second phase is when the ground contact of support leg up to the smallest knee angle of pushing leg while the last phase is started when the smallest knee angle of swinging leg until ball impact. From the data, velocity, acceleration, distance of ball towards force, angle of hip and angle of knee to make a success double instep kick within two conditions which are with and without knee pad can be analyzed.

Data were analyzed by using Silicon Coach Pro's software. Velocity, acceleration and distance of ball can be analyzed to see which of them that is significance to force model. Biggest angle of hip and angle of knee compared between one step and two steps run while using knee pad or without using knee pad. Multiple linear modeling equations are used to analyze relationship between distance, velocity and acceleration of kicking. The statistical analysis which are correlation and ANOVA analysis were conducted by using Minitab and SPSS software.

3.5 CONCLUSION

As to conclude the methodology process, there will be 12 subjects with good health involved in this study. The experiment set up was as in Figure 3.2 and Figure 3.5. Six of the subjects were applied one step and two steps run of instep kick with knee pad while the other six subjects applied one step and two steps run of instep kick without knee pad where each of them had to do three trials for each step run. All of them used their preferred leg while doing the kicking. Subjects were answered the questionnaire given to them for their anthropometric data and their perception towards knee pad usage. Two high speed cameras were focused on their lower limbs before their doing the kicking until it was done. The ball velocity, acceleration and distance were taken after that. These kicking videos were analyzed by Silicon Pro Coach software and the statistical analysis was analyzed by using Minitab software.

The angle of knee and hip analyzed when synchronizing the picture of the subject when kicking based on front camera and side camera that had been focusing on their lower limb. The correlation, force equation and multi linear regression got from the data of the kicking.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

Analysis of studies conducted in this study is described in this chapter. The results obtained from taking pictures as well as statistical calculations will be performed on the data. The results of the study will be analyzed using Silicon Coach Pro and Minitab and SPSS software to obtain the force model that can be developed and compare variables between using knee pad and without using knee pad when performed the double instep kick.

4.2 SEGMENT WEIGHT SUBJECTS

In calculating the weight of the subject segment, an equation will be used to calculate the mass of the segments of the kicking leg. Anthropometry data for each subject should be recorded in order to get the mass of the foot. There are many equations to calculate body segment in which it is different for the two-dimensional (2D) and three-dimensional (3D). Mass of the foot is important to get the force generated by the subject of a kick.

Equations for the mass of kicking legs were taken from the book of Research Method in Biomechanic (Gorldon *et al*., 2004). In essence, a mass for the segment in the structure of the body which is the lower limb is divided into three mass will be added together. They are mass foot, calf mass and the mass of the thigh. Below is the equation that will be used to calculate the mass of the segments of the kicking leg.

The equations are:

$$\mathbf{m_{foot}} = 0.0083\ m_{total} + 254.5\ (l_{sole}\ h_{malleolus}\ \omega_{malleolus}) - 0.065 \quad (4.1)$$

$$\mathbf{m_{calf}} = 0.0226\ m_{total} + 31.33\ (l_{calf}\ c^2_{calf}) + 0.016 \quad (4.2)$$

$$\mathbf{m_{thigh}} = 0.1032\ m_{total} + 12.76\ (l_{thigh}\ c^2_{thigh}) + 1.032 \quad (4.3)$$

where,

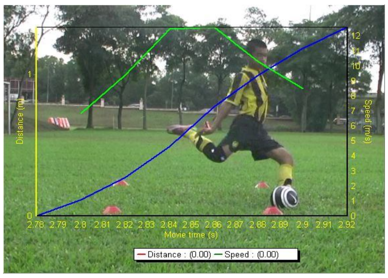
m_{total} = total body mass ; $h_{malleolus}$ = malleolus height ; $\omega_{malleolus}$ = malleolus width ; c_{thigh} = midthigh circumference (diameter of the thigh) ; c_{calf} : calf circumference (diameter of the calf) ; l = length of each segment.

4.3 PICTURE OF KICKING

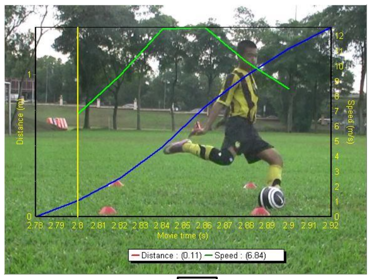
Observation had been done by taking video while subject doing the experiment and had been edited for the analysis by using the Silicon Pro Coach software. Each frame for every 0.02 seconds from before the subject kick the ball until kicking is done. The subject will be recorded by using two cameras where a camera is placed in the position of the front and one placed at the side of the study area. These two cameras are used to obtain a clear picture on the lower body segment subject to further analysis. Through this research, we can see how the position and direction of movement of the subject body while doing a kick from the front and sides. Markers were attached at the waist, knees and ankles subjects for analysis purposes.

4.3.1 Picture of subject with knee pad

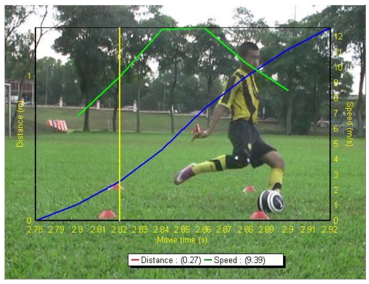
Every subject performed double instep kick was captured by two high speed camera from in front view and side view of the subject that focusing on their lower limb. Each frame for every 0.02 seconds from before the subject kick the ball until kicking is done where the subject is assigned to use knee pad.



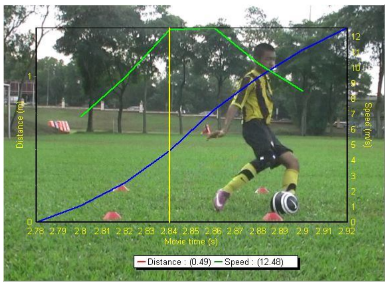
Frame 1



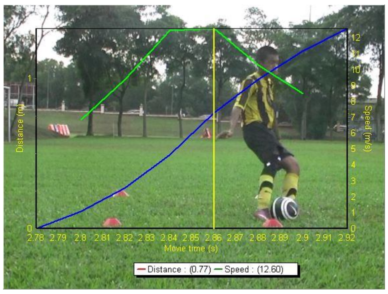
Frame 2



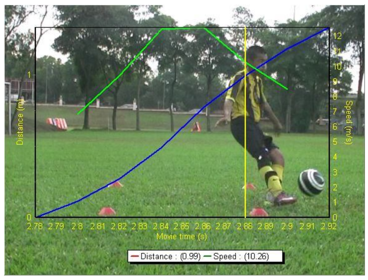
Frame 3



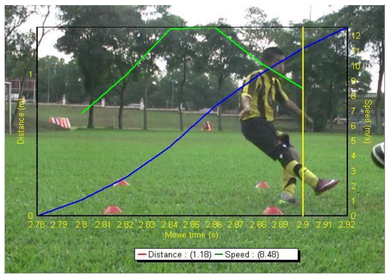
Frame 4



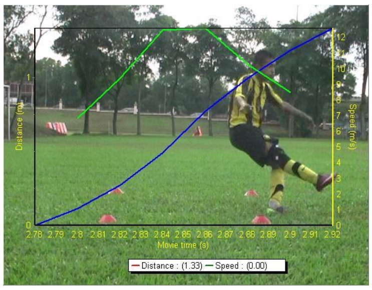
Frame 5



Frame 6



Frame 7



Frame 8

Figure 4.1: Picture from side view of subject from start to kick until finish performing instep kick with knee pad

4.3.2 Picture of subject without knee pad

Every subject performed double instep kick was captured by two high speed camera from in front view and side view of the subject that focusing on their lower limb. Each frame for every 0.02 seconds from before the subject kick the ball until kicking is done where the subject is assigned to perform without using knee pad.

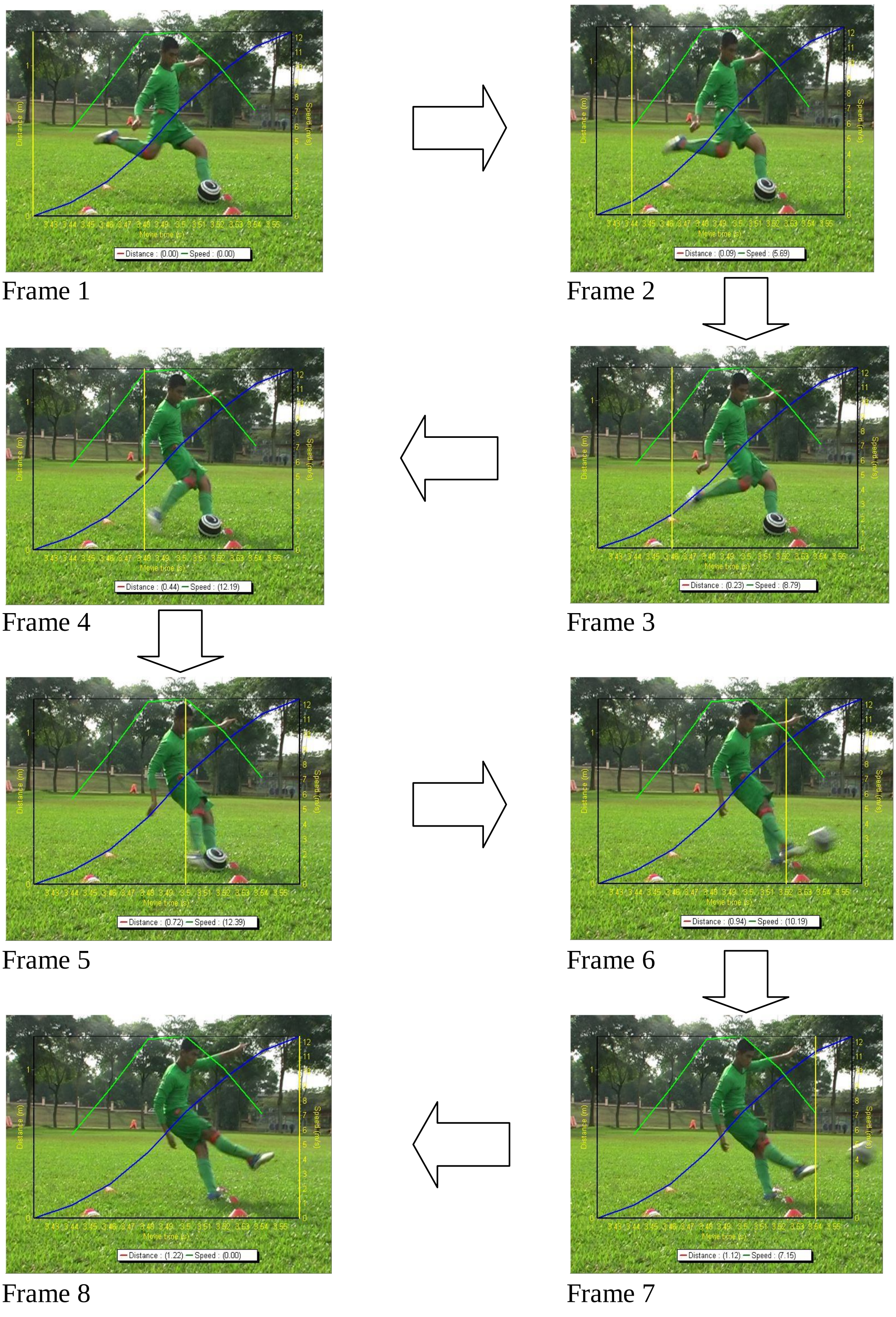


Figure 4.2: Picture from side view of subject from start to kick until finish performing instep kick without knee pad

4.4 CALCULATION OF MASS OF SUBJECTS AND FORCE

To calculate $m_{segment}$ for Equation 4.4, m_{foot}, m_{calf} and m_{thigh} had to be considered. They are as follows.

Table 4.1: Mass of subjects

Player	Mass (kg)
1	60
2	58
3	49
4	56
5	62
6	48
7	65
8	65
9	78
10	75
11	74
12	64
Average	62.8333333

The average total weight for all the subjects involve in the experiment that had been conducted will be m_{total} = 62.8kg.

l_{sole} = 0.26 m, $h_{malleolus}$ = 0.08, $\omega_{malleolus}$ = 0.07, l_{calf} = 0.45m, c_{calf} = 0.40, l_{thigh} = 0.47m, c_{thigh} = 0.56

As for the calculation for $m_{segment}$ is $m_{segment} = m_{foot} + m_{calf} + m_{thigh}$

$\mathbf{m_{foot}} = 0.0083\ m_{total} + 254.5\ (l_{sole}\ h_{malleolus}\ \omega_{malleolus}) – 0.065$

$\mathbf{m_{foot}} = 0.0083(62.8kg) + 254.5\ (0.26m \times 0.08 \times 0.07) – 0.065$

$\mathbf{m_{foot}} = 0.8268$ kg

$\mathbf{m_{calf}} = 0.0226\ m_{total} + 31.33\ (l_{calf}\ c^2_{calf}) + 0.016$

$\mathbf{m_{calf}} = 0.0226(62.8kg)+ 31.33\ (0.45m \times 0.40^2) + 0.016$

$\mathbf{m_{calf}} = 3.6910$ kg

$\mathbf{m_{thigh}} = 0.1032\ m_{total} + 12.76\ (l_{thigh}\ c^2_{thigh}) + 1.032$

$\mathbf{m_{thigh}} = 0.1032(62.8kg)+ 12.76\ (0.47m \times 0.56^2) + 1.032$

$\mathbf{m_{thigh}} = 9.3937$ kg

$\mathbf{m_{segment}} = m_{foot} + m_{calf} + m_{thigh}$

$\mathbf{m_{segment}}$ =0.8268 kg + 3.6910 kg + 9.3937 kg

$\mathbf{m_{segment}}$ = 13.9115 kg

4.4.1 Example for calculation of force to the ball

Example for calculation of force to the ball is as follows:

$$\mathbf{F} = mV / \Delta t \qquad (4.4)$$

Where F = force, m= mass of foot that kick the ball, V= velocity while kicking, and Δ t= time difference per frame

F = (13.9115kg x 10.2411 m/s) / 0.02

F = 7123.45 N

4.5 DATA COLLECTION OF VELOCITY, ACCELERATION, DISTANCE, ANGLE OF HIP AND ANGLE OF KNEE

The data collections of velocity, acceleration, distance, angle of hip and angle of knee were made at ISN. The entire subject required to performed double instep kick which is one step and two steps run towards the ball by using knee pad and without knee pad. Then, comparison was made between those differences.

4.5.1 Comparison of ball velocity between kicking double instep kick using knee pad and without knee pad

This is the comparison of ball velocity in two conditions while performing double instep kick which is with knee pad and without knee pad.

Table 4.2: Ball velocity between kicking double instep kick using knee pad and without knee pad

Activity	Ball velocity with knee pad (m/s)	Ball velocity without knee pad (m/s)
One step run	10.2411	12.4000
Two step run	10.4578	12.6061

From the Table 4.2, it shows that the ball velocity is much higher when performing one step run and two steps run without using knee pad. For one step run, the ball velocity is 12.4 m/s much higher than the ball velocity when applying one step run towards the ball which is 10.2411 m/s while for two step run, the ball velocity also much higher, 12.6061 m/s rather than when subject using knee pad which is 10.4578 m/s. With this, it shows that the highest velocity can be achieved when performing two step run and without using knee pad.

4.5.2 Comparison of ball acceleration between kicking double instep kick using knee pad and without knee pad

This is the comparison of ball acceleration in two conditions while performing double instep kick which is with knee pad and without knee pad.

Table 4.3: Ball acceleration between kicking double instep kick using knee pad and without knee pad

Activity	Ball acceleration with knee pad (m/s2)	Ball acceleration without knee pad (m/s2)
One step run	496.44	620.00
Two step run	522.89	630.31

As for Table 4.3, it is about comparison of ball acceleration between one step run and two step run when subject is using knee pad or without using knee pad. From the table, it shows that the ball acceleration is much higher when subject perform the one step run without using knee pad which is 620 m/s2 rather than using knee pad which is 496.44 m/s2. Same goes when subject applying it on two step run and perform instep kick. Subject that using the knee pad gave lower acceleration value which is 522.89 m/s2 rather than without using knee pad, 630.31 m/s2. Thus, it clearly showed that the highest acceleration occur when the subject performing instep kick with two step run and without using knee pad.

4.5.3 Comparison of ball distance after kicking double instep kick using knee pad and without knee pad

This is the comparison of ball distance in two conditions while performing double instep kick which is with knee pad and without knee pad. It is as indicated in Table 4.4.

Table 4.4: Ball distance after kicking double instep kick using knee pad and without knee pad

Activity	**Ball distance with knee pad (m)**	**Ball distance without knee pad (m)**
One step run	38.4889	36.7444
Two step run	43.6944	48.4611

For ball distance comparison, there is a little bit difference where for one step run, the value for ball distance is much higher, 38.4889 m when using knee pad rather than not using it, 36.7444 m while for two steps run, the value of distance is much more higher without using knee pad while performing instep kick which is 48.4611 m compared the subject using knee pad which is 43.6944 m. The highest value of distance here is when performing instep kick with two step run and without using knee pad which is 48.4611 m.

4.5.4 Comparison of angle of hip and knee while kicking double instep kick using knee pad and without knee pad

This is the comparison of angle of hip and knee in two conditions while performing double instep kick which is with knee pad and without knee pad. It is as indicated in Table 4.5.

Table 4.5: Angle of hip and knee while kicking double instep kick using knee pad and without knee pad

Activity	Angle with knee pad (°)		Angle without knee pad (°)	
	hip	**Knee**	**hip**	**knee**
One step run	140.5556	149.6667	134.6667	148.0556
Two step run	139.3333	153.0000	136.4444	146.6111

From Table 4.5, it shows that the angle of hip is much bigger when performing one step run and with knee pad which showed 140.56 ° compared to one step kick without using knee pad. Same goes to two steps run where the angle of hip also much bigger when subject is using knee pad, 139.3333 ° rather than without using knee pad, 136.4444 °.

For angle of knee, it was also bigger when the subject is performing one step run towards the ball by using knee pad compared to not using it which is 149.6667 ° than 148.0556 °. For two steps run, it also gives the same perception where the angle of knee is much bigger when using knee pad rather than not using it which is 153.00 ° compared to 146.6111 °. With this, it shows that the biggest hip angle occurred when performing one step run and with the knee pad and the biggest knee angle occurred when applying two steps run while using knee pad.

4.5.5 Discussion on comparison with and without using knee pad

The data collected were then compared in both situations whereas using knee pad or without using knee pad while performing double instep kick that consists of one step run and two steps run. From that, it shows that the highest velocity, acceleration and distance can be achieved when performing two step run and without using knee pad. They are 12.6061 m/s, 630.31 m/s2 and 48.4611 m. They were a little bit difference compared to previous study by Ismail and colleagues that got highest average velocity is 8.2 m/s with kicking distance achieved up to 47.85 m by using three steps run.

Previous study by Ozaki and Aoki (2007) stated that there are many practical ways to increase the release velocity of the ball. Kicker can only affect the ball while the kicking foot touches the ball. The behavior of the ball is decided by positional relation between kicking foot and the ball and moving direction and velocity of kicking foot. Higher release velocity of the ball can be reached by increasing the velocity of the foot mechanically for the contact phase with foot and ball which by leaning the body away from the ball and balancing the body with extended arms during the kicking movement. As from the value of ball velocity that shown in table above, it shows higher velocity when performing two step run and without using knee pad maybe due to no barrier to the foot itself and easier to move the foot as fast as the subject want when performing the kick.

Kicking from an approach angle of 45 ° to 60 ° may alter aspects of technique, such as enhancing pelvic rotation, and thigh abduction of kicking leg at impact which is better ball contact and may increase ball speed (Lees and Nolan, 1998; Barfield, 1998; Scurr and Hall, 2009). Kicking with running approach demonstrates higher ball speed values compared with static approach kicks (Opavsky, 1988). Those were what had been applied in this study where the subject kick the ball from an approach angle of 45° and also running with one step and two step and it showed two step give higher value.

4.6 CORRELATION AND ANOVA ANALYSIS

All of the data that had been collected were transferred into Minitab software to be analyzed to see the connection between all of the variables involved from the double instep kicking.

4.6.1 One step with knee pad

For one step with knee pad, the graph in Figure 4.3, Figure 4.4 and Figure 4.5 that had been analyzed were force versus velocity, force versus acceleration, and force versus distance.

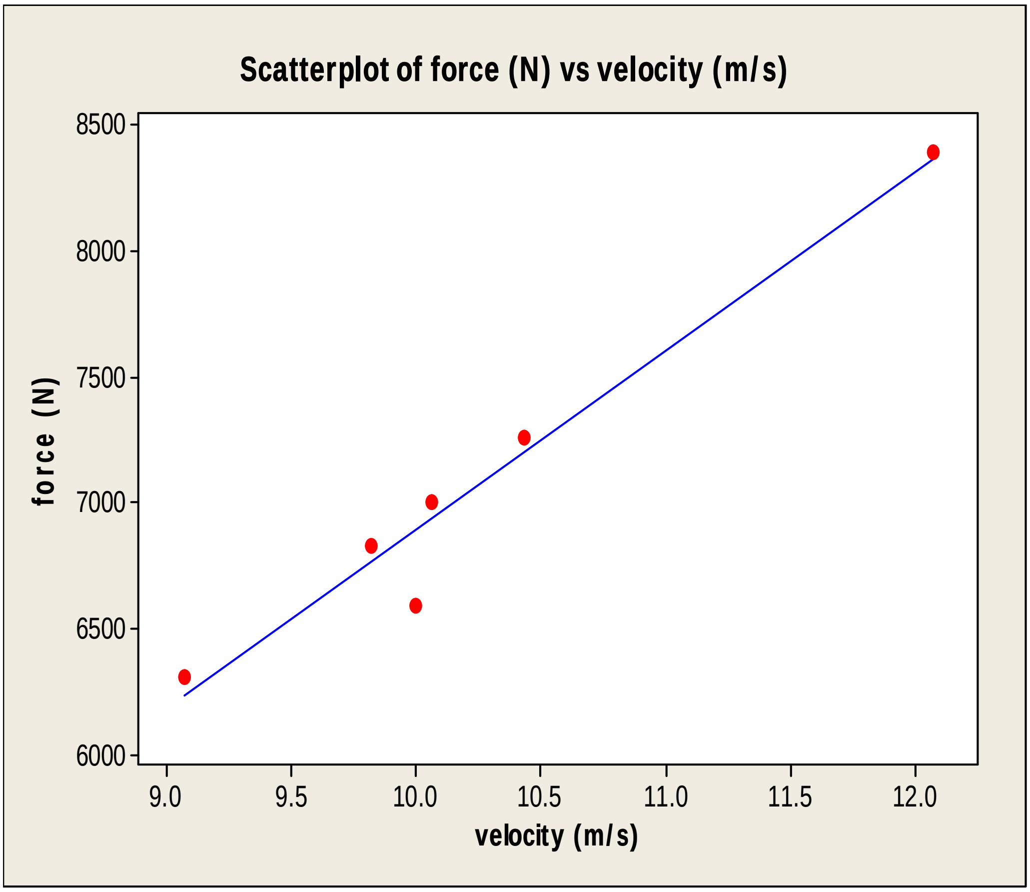


Figure 4.3: Graph of force versus velocity

From Figure 4.3 of force versus velocity graph, it shows the data in the form of irregular but evenly. This means that the variables can be accepted as significant.

For the correlation analysis, correlation coefficient, r is 0.980 as in Table 4.6, which showed a high and strong relationship line between the amount of force as the dependent variable and velocity as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and velocity, R^2 = 0.960 and output report R^2 x 100 % = 96 %. Regression model accounts for 96 % state variable in the effort.

Table 4.6: Correlation analysis, regression analysis, ANOVA, t-test (one step with knee pad-force versus velocity)

Correlation analysis

		Force	Velocity
Force	Pearson Correlation	1	0.980(**)
	Sig. (2-tailed)		0.001
	N	6	6
Velocity	Pearson Correlation	0.980(**)	1
	Sig. (2-tailed)	0.001	
	N	6	6

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.980(a)	0.960	0.950	163.10140

Predictors: (Constant), velocity

ANOVA

Source	DF	SS	MS	F	P
Regression	1	2557592	2557592	96.14	0.001
Residual error	4	106408	26602		
Total	5	2664000			

T-test

Predictor	Coefficient	SE Coef	T	P
Constant	-241.7	748.0	-0.32	0.763
Velocity (m/s)	713.32	72.75	9.81	0.001

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between velocity and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between velocity and force is important)

The regression equation is

Force (N) = - 241.7 + 713.32 velocity (m/s)

y = 713.32 x – 241.7

From Minitab, the output state estimate model parameters smallest square is b_0 = - 241.7 and b_1 = 713.32.

P- Value = 0.001

P- Value $< \alpha = 0.05$

Reject H_0

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-velocity model is important. Thus, we can conclude that there is a straight relationship between force and velocity. A t-test was conducted to determine the importance of regression coefficients. For the t-value, the value of the velocity is 9.81 and the p-value of 0.001. These important values below the regression tests showed that the velocity of the importance of contributing to the model.

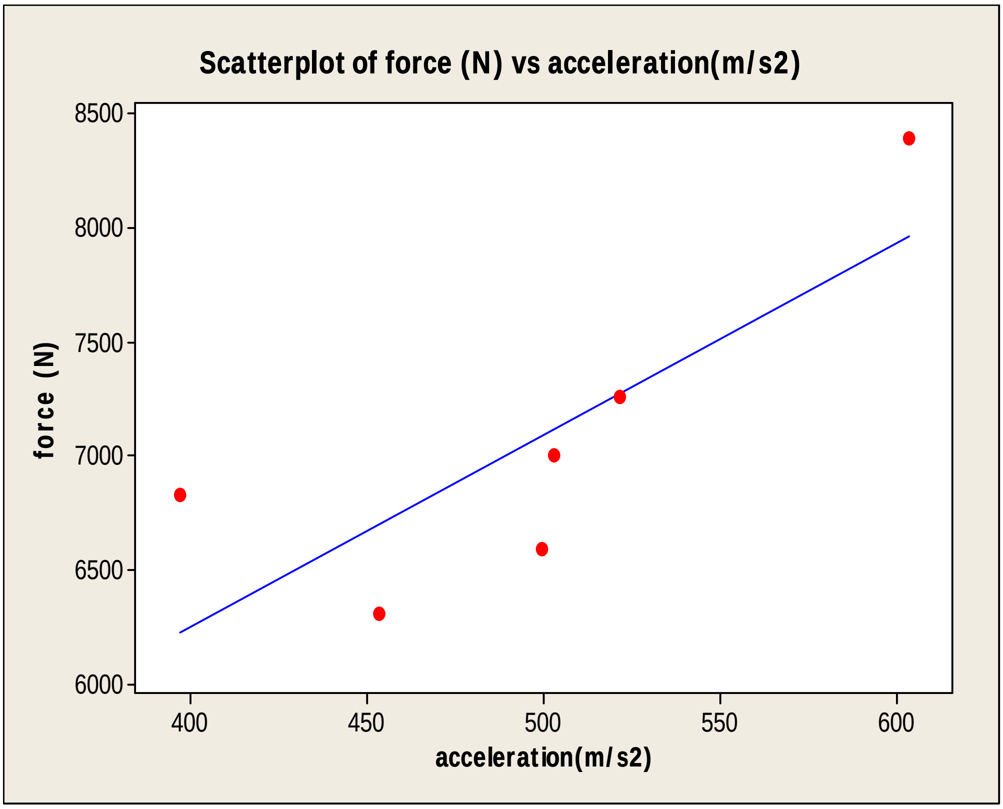


Figure 4.4: Graph of force versus acceleration

From the Figure 4.4 of force versus acceleration graph above, it shows the data in the form of irregular but evenly. This means that the variables can be accepted as significant.

For the correlation analysis, correlation coefficient, r is 0.798 as in Table 4.7, which showed a strong relationship line between the amount of force as the dependent variable and acceleration as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and acceleration, $R^2 = 0.638$ and output report $R^2 \times 100\% = 63.8\%$. Regression model accounts for 100% state variable in the effort.

Table 4.7: Correlation analysis, regression analysis, ANOVA, t-test (one step with knee pad-force versus acceleration)

Correlation analysis

		Force	**Acceleration**
Force	Pearson Correlation	1	0.798
	Sig. (2-tailed)		0.057
	N	6	6
Acceleration	Pearson Correlation	0.798	1
	Sig. (2-tailed)	0.057	
	N	6	6

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.798(a)	0.638	0.547	491.29630

Predictors: (Constant), acceleration

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	3107907	3107907	14.43	0.013
Residual error	5	1077150	215430		
Total	6	4185057			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	2338	1306	1.79	0.133
Acceleration(m/s2)	9.605	2.529	3.80	0.013

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between acceleration and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between acceleration and force is important)

The regression equation is

Force (N) = 2338 + 9.605 acceleration (m/s2)

y = 9.605 x + 2338

From Minitab, the output state estimate model parameters smallest square is b_0 = 2338 and b_1 = 9.605.

P- Value = 0.013

P- Value $< \alpha$ = 0.05

Reject H_0.

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-acceleration model is important. Thus, we can conclude that there is a straight relationship between force and acceleration. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the acceleration is 3.80 and the p-value of 0.013. These important values below the regression tests showed that the acceleration of the importance of contributing to the model.

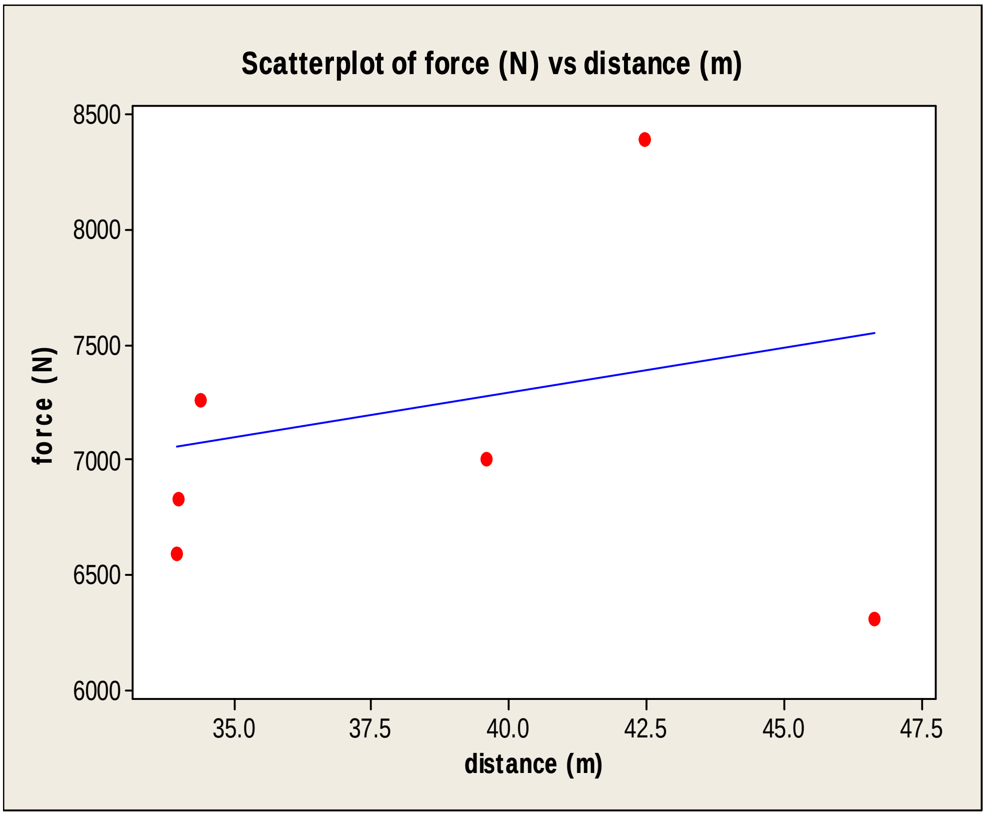


Figure 4.5: Graph of force versus distance

From the Figure 4.5 above of force versus distance, it shows the graph is plotted is not uniform and continuous. So this shows that these variables cannot be accepted and not significant.

For the correlation analysis, correlation coefficient, r is 0.077 as in Table 4.8, which showed a weak relationship line between the amount of force as the dependent variable and distance as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and distance, $R^2 = 0.006$ and output report $R^2 \times 100\ \% = 0.6\ \%$. Regression model accounts for 0.6 % state variable in the effort.

Table 4.8: Correlation analysis, regression analysis, ANOVA, t-test (one step with knee pad-force versus distance)

Correlation analysis

		Force	Distance
Force	Pearson Correlation	1	0.077
	Sig. (2-tailed)		0.884
	N	6	6
Distance	Pearson Correlation	0.077	1
	Sig. (2-tailed)	0.884	
	N	6	6

Regression analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.077(a)	0.006	-0.243	813.64362

Predictors: (Constant), distance

ANOVA

Source	DF	SS	MS	F	P
Regression	1	235539	235539	0.30	0.608
Residual error	5	3949518	789904		
Total	6	4185057			

t- Test

Predictor	Coef	SE Coef	T	P
Constant	5732	2808	2.04	0.097
Distance (m)	38.97	71.37	0.55	0.608

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between distance and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between distance and force is important)

The regression equation is

Force (N) = 5732 + 38.97 distance (m)

y = 38.97x + 5732

From Minitab, the output state estimate model parameters smallest square is b_0 = 5732 and b_1 = 38.97.

P- Value = 0.608

P- Value > α = 0.05

Accept H_0.

Because the p-value is bigger than 0.05, we cannot reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-distance model is not important. Thus, we can conclude that there is no straight relationship between force and distance. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the distance is 0.55 and the p-value of 0.608. These important values below the regression tests showed that the distance does not contribute to the importance of regression to model.

4.6.2 One step without knee pad

For one step without knee pad, the graph in Figure 4.6, Figure 4.7 and Figure 4.8 that had been analyzed were force versus velocity, force versus acceleration, and force versus distance.

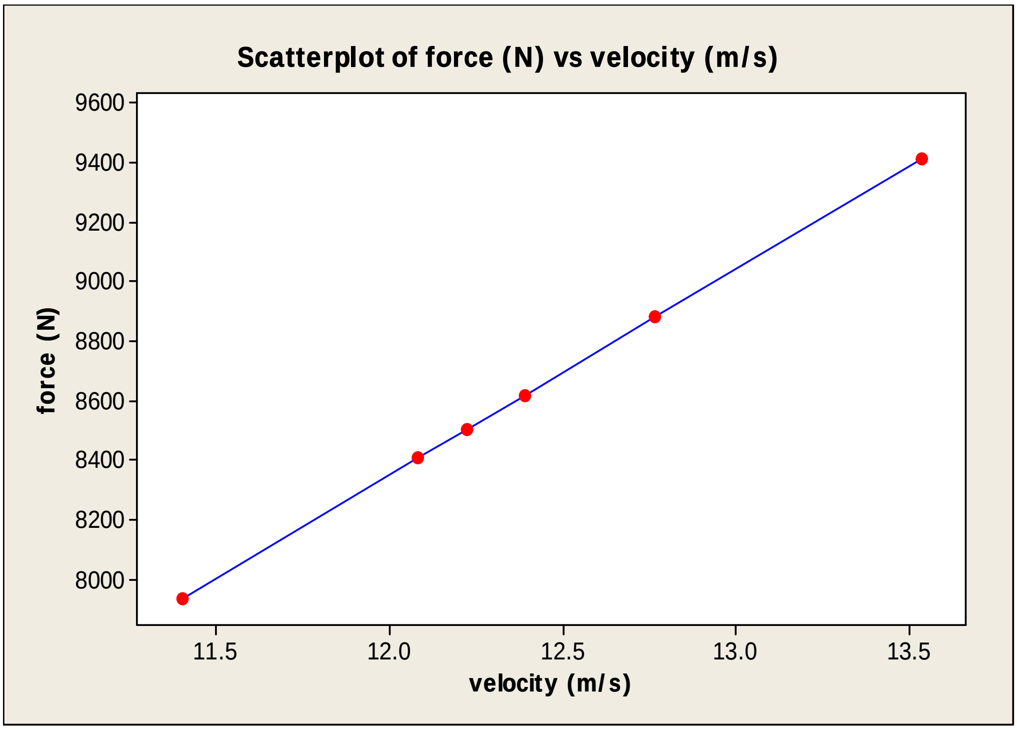


Figure 4.6: Graph of force versus velocity

Figure 4.6 shows a graph of force versus velocity for one step and without using a knee pad. From the figure can show that the force is proportional to the velocity of the kick velocity which is the higher the velocity, the greater the force produced.

For the correlation analysis, correlation coefficient, r is 1.000 as in Table 4.9, which showed a high and strong relationship line between the amount of force as the dependent variable and velocity as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and velocity, $R^2 = 1.000$ and output report $R^2 \times 100 \% = 100 \%$. Regression model accounts for 100 % state variable in the effort.

Table 4.9: Correlation analysis, regression analysis, ANOVA, t-test (one step without knee pad-force versus velocity)

Correlation analysis

		Force	**Velocity**
Force	Pearson Correlation	1	1.000(**)
	Sig. (2-tailed)		0.000
	N	6	6
Velocity	Pearson Correlation	1.000(**)	1
	Sig. (2-tailed)	0.000	
	N	6	6

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.02334

Predictors: (Constant), Velocity

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	1230759	1230759	2.25942E+09	0.000
Residual error	4	0	0		
Total	5	1230759			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	0.1094	0.1817	0.60	0.579
Velocity (m/s)	695.567	0.015	47533.36	0.000

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between velocity and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between velocity and force is important)

The regression equation is

Force (N) = 0.1094 + 695.6 velocity (m/s)

y = 695.6 x + 0.1094

From Minitab, the output state estimate model parameters smallest square is b_0 = 0.1094 and b_1 = 695.567

P- Value = 0.000

P- Value $< \alpha = 0.05$

Reject H_0.

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-velocity model is important. Thus, we can conclude that there is a straight relationship between force and velocity. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the acceleration is 47533.36 and the p-value of 0.000. These important values below the regression tests showed that the veocity of the importance of contributing to the model.

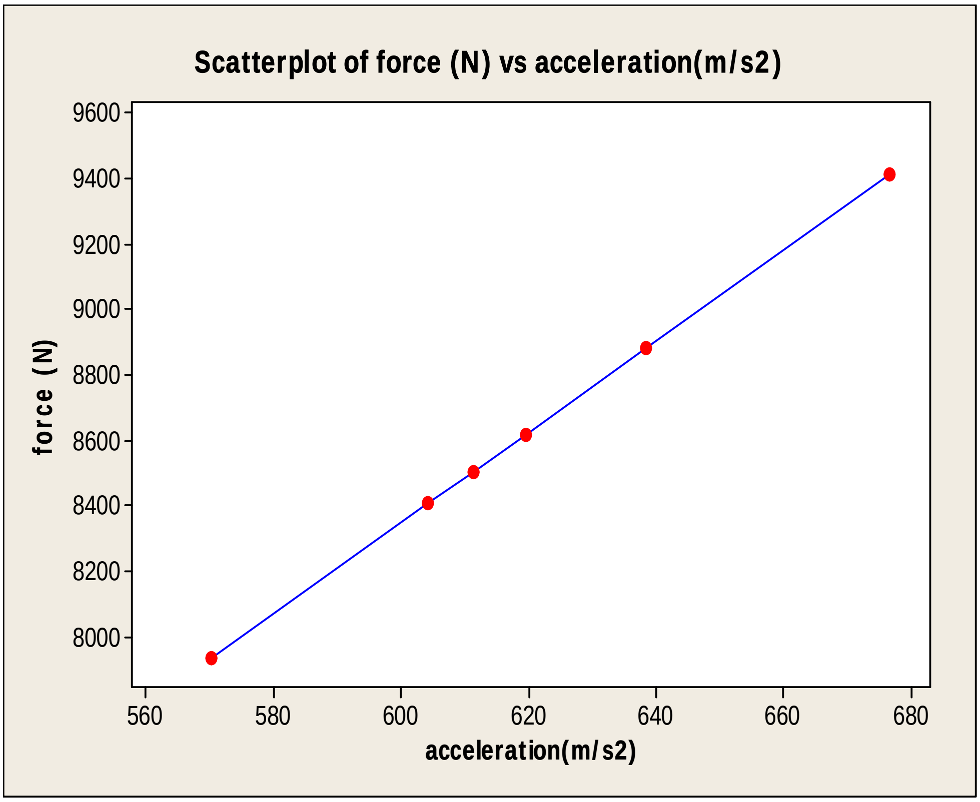


Figure 4.7: Graph of force versus acceleration

Figure 4.7 shows a graph of force versus acceleration for one step and without using a knee pad. From the figure can show that the force is proportional to the acceleration which is the higher the acceleration, the greater the force produced.

For the correlation analysis, correlation coefficient, r is 1.000 as in Table 4.10, which showed a high and strong relationship line between the amount of force as the dependent variable and acceleration as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and acceleration, $R^2 = 1.000$ and output report $R^2 \times 100\% = 100\%$. Regression model accounts for 100% state variable in the effort.

Table 4.10: Correlation analysis, regression analysis, ANOVA, t-test (one step without knee pad-force versus acceleration)

Correlation analysis

		Force	**Acceleration**
Force	Pearson Correlation	1	1.000(**)
	Sig. (2-tailed)		0.000
	N	6	6
Acceleration	Pearson Correlation	1.000(**)	1
	Sig. (2-tailed)	0.000	
	N	6	6

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.04056

Predictors: (Constant), acceleration

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	1230759	1230759	7.48045E+08	0.000
Residual error	4	0	0		
Total	5	1230759			

T-test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	-0.1706	0.3158	-0.54	0.618
Acceleration(m/s2)	13.9117	0.0005	27350.42	0.000

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between acceleration and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between acceleration and force is important)

The regression equation is

Force (N) = - 0.1706 + 13.91 acceleration (m/s2)

y = 13.91x - 0.1706

From Minitab, the output state estimate model parameters smallest square is b_0 = - 0.1706   and b_1 = 13.9117

P- Value = 0.000

P- Value $< \alpha = 0.05$

Reject H_0.

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-acceleration model is important. Thus, we can conclude that there is a straight relationship between force and acceleration. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the acceleration is 27350.42 and the p-value of 0.000. These important values below the regression tests showed that the acceleration of the importance of contributing to the model.

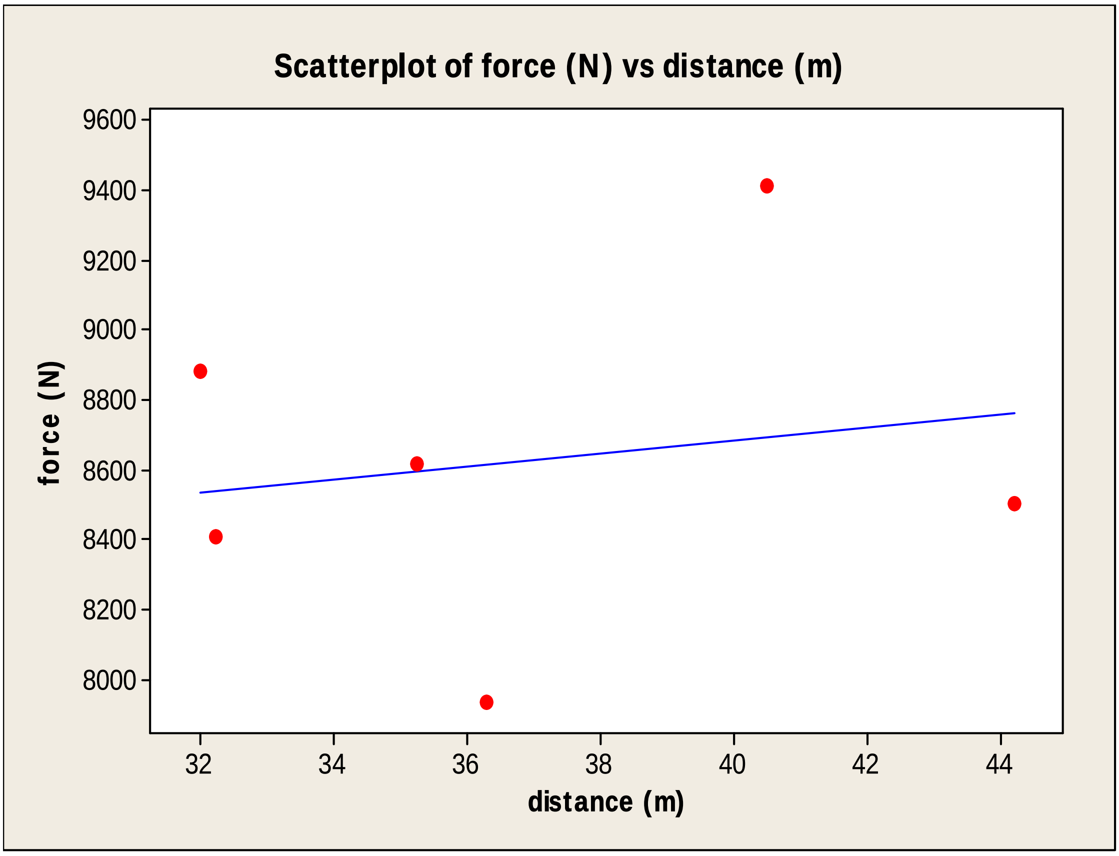


Figure 4.8: Graph of force versus distance

From Figure 4.8 above of force versus distance graph, it shows the graph is plotted is not uniform and continuous. So this shows that these variables cannot be accepted and not significant.

For the correlation analysis, correlation coefficient, r is 0.180 as in Table 4.11, which showed a weak relationship line between the amount of force as the dependent variable and distance as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and distance, $R^2 = 0.033$ and output report $R^2 \times 100\ \% = 3.3\ \%$. Regression model accounts for 3.3 % state variable in the effort.

Table 4.11: Correlation analysis, regression analysis, ANOVA, t-test (one step without knee pad-force versus distance)

Correlation analysis

		Force	**Distance**
Force	Pearson Correlation	1	0.180
	Sig. (2-tailed)		0.732
	N	6	6
Distance	Pearson Correlation	0.180	1
	Sig. (2-tailed)	0.732	
	N	6	6

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.180(a)	0.033	-0.209	545.59582

Predictors: (Constant), distance

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	40059	40059	0.13	0.732
Residual error	4	1190699	297675		
Total	5	1230759			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	7939	1882	4.22	0.014
Distance (m)	18.66	50.87	0.37	0.732

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between distance and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between distance and force is important)

The regression equation is

Force (N) = 7939 + 18.66 distance (m)

$y = 18.66\ x - 7939$

From Minitab, the output state estimate model parameters smallest square is b_0 = 7939 and b_1 = 18.66 .

P- Value = 0.732

P- Value > α = 0.05

Accept H_0.

Because the p-value is bigger than 0.05, we cannot reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-distance model is not important. Thus, we can conclude that there is no straight relationship between force and distance. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the distance is 0.37 and the p-value of 0.732. These important values below the regression tests showed that the distance does not contribute to the importance of regression to model.

4.6.3 Two step with knee pad

For two steps with knee pad, the graph of Figure 4.9, Figure 4.10 and Figure 4.11 that had been analyzed were force versus velocity, force versus acceleration, and force versus distance.

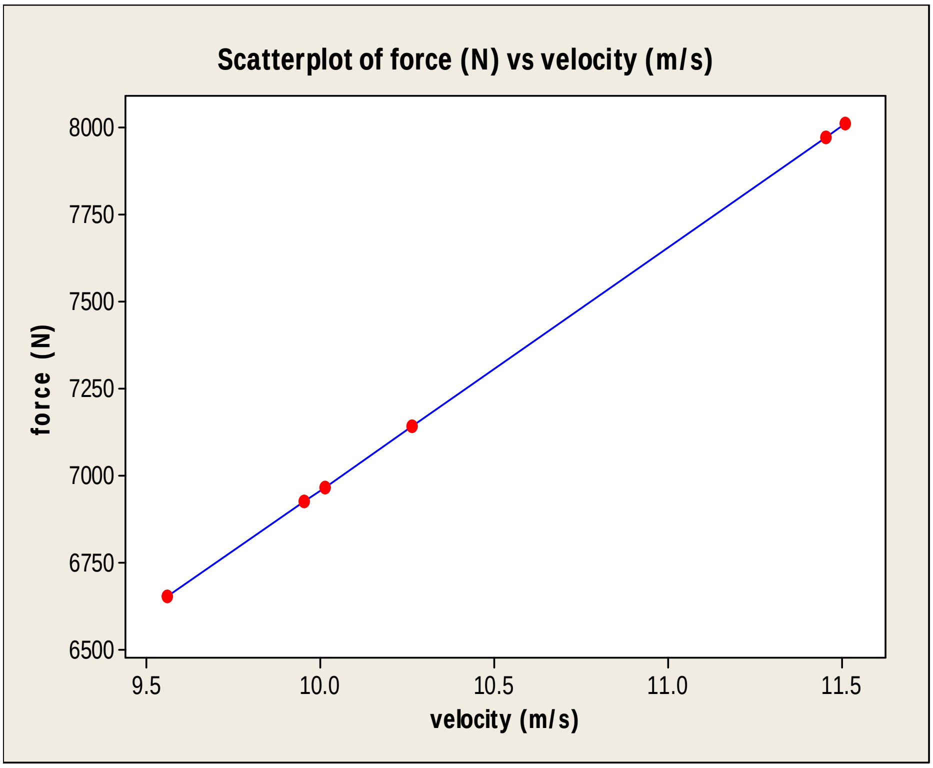


Figure 4.9: Graph of force versus velocity

Figure 4.9 shows a graph of force versus velocity for two steps and with using a knee pad. From the figure can show that the force is proportional to the velocity of the kick velocity which is the higher the velocity, the greater the force produced.

For the correlation analysis, correlation coefficient, r is 1.000 as in Table 4.12, which showed a high and strong relationship line between the amount of force as the dependent variable and velocity as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and velocity, R^2 = 1.000 and output report R^2 x 100 % = 100 %. Regression model accounts for 100% state variable in the effort.

Table 4.12: Correlation analysis, regression analysis, ANOVA, t-test (two steps with knee pad-force versus velocity)

Correlation analysis

		Force	**Velocity**
Force	Pearson Correlation	1	1.000(**)
	Sig. (2-tailed)		0.000
	N	6	6
Velocity	Pearson Correlation	1.000(**)	1
	Sig. (2-tailed)	0.000	
	N	6	6

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.02022

Predictors: (Constant), velocity

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	1651340	1651340	4.03941E+09	0.000
Residual error	4	0	0		
Total	5	1651340			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	0.0247	0.1147	0.22	0.840
Velocity (m/s)	695.572	0.011	63556.39	0.000

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between velocity and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between velocity and force is important)

The regression equation is

Force (N) = 0.0247 + 695.6 velocity (m/s)

y = 695.6 x - 0.0247

From Minitab, the output state estimate model parameters smallest square is b_0 = 0.0247 and b_1 = 695.572.

P- Value = 0.000

P- Value $< \alpha = 0.05$

Reject H_0.

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-velocity model is important. Thus, we can conclude that there is a straight relationship between force and velocity. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the acceleration is 63556.39 and the p-value of 0.000. These important values below the regression tests showed that the velocity of the importance of contributing to the model.

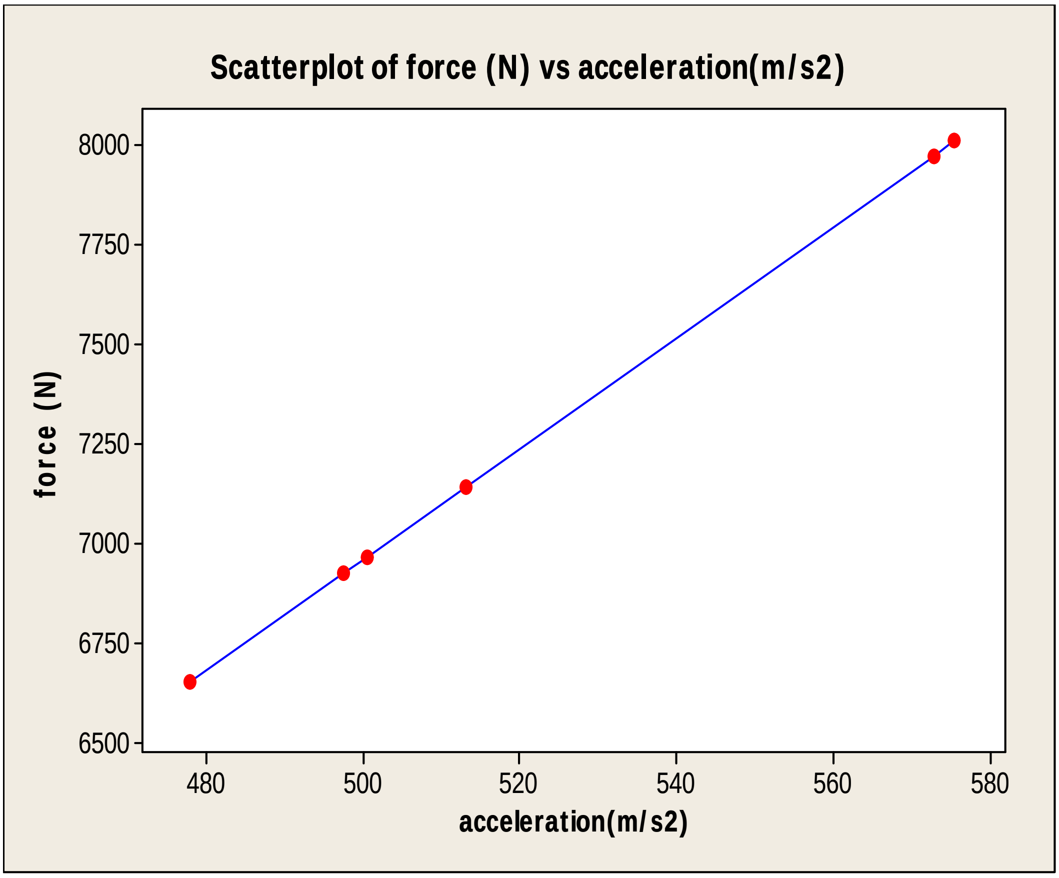


Figure 4.10: Graph of force versus acceleration

Figure 4.10 shows a graph of force versus acceleration for two steps and with using a knee pad. From the figure can show that the force is proportional to the acceleration which is the higher the acceleration, the greater the force produced.

For the correlation analysis, correlation coefficient, r is 1.000 as in Table 4.13, which showed a high and strong relationship line between the amount of force as the dependent variable and acceleration as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and acceleration, R^2 = 1.000 and output report R^2 x 100 % = 100 %. Regression model accounts for 100 % state variable in the effort.

Table 4.13: Correlation analysis, regression analysis, ANOVA, t-test (two steps with knee pad-force versus acceleration)

Correlation analysis

		Force	**Acceleration**
Force	Pearson Correlation	1	1.000(**)
	Sig. (2-tailed)		0.000
	N	6	6
Acceleration	Pearson Correlation	1.000(**)	1
	Sig. (2-tailed)	0.000	
	N	6	6

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.03823

Predictors: (Constant), acceleration

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	1651340	1651340	1.12990E+09	0.000
Residual error	4	0	0		
Total	5	1651340			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	-0.0260	0.2170	-0.12	0.910
Acceleration(m/s2)	13.9116	0.0004	33613.93	0.000

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between acceleration and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between acceleration and force is important)

The regression equation is

Force (N) = - 0.0260 + 13.91 acceleration (m/s2)

$y = 13.91\,x - 0.0260$

From Minitab, the output state estimate model parameters smallest square is $b_0 = -0.0260$ and $b_1 = 13.9116$.

P- Value = 0.000

P- Value $< \alpha = 0.05$

Reject H_0.

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-acceleration model is important. Thus, we can conclude that there is a straight relationship between force and acceleration. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the acceleration is 33613.93 and the p-value of 0.000. These important values below the regression tests showed that the acceleration of the importance of contributing to the model.

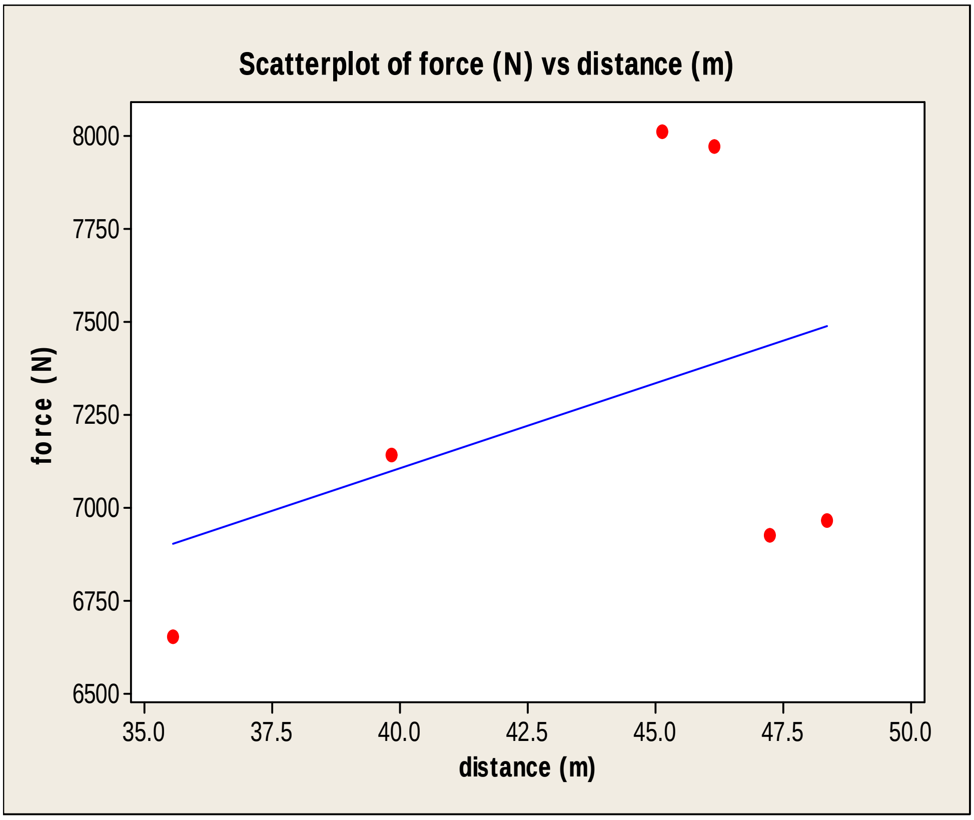


Figure 4.11: Graph of force versus distance

From the Figure 4.11 above of force versus distance graph, it shows the graph is plotted is not uniform and continuous. So this shows that these variables cannot be accepted and not significant.

For the correlation analysis, correlation coefficient, r is 0.398 as in Table 4.14, which showed a low relationship line between the amount of force as the dependent variable and distance as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and distance, $R^2 = 0.159$ and output report $R^2 \times 100$ % = 15.9 %. Regression model accounts for 15.9 % state variable in the effort.

Table 4.14: Correlation analysis, regression analysis, ANOVA, t-test (two steps with knee pad-force versus distance)

Correlation analysis

		Force	**Distance**
Force	Pearson Correlation	1	0.398
	Sig. (2-tailed)		0.434
	N	6	6
Distance	Pearson Correlation	0.398	1
	Sig. (2-tailed)	0.434	
	N	6	6

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.398(a)	0.159	-0.052	589.37166

Predictors: (Constant), distance

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	261905	261905	0.75	0.434
Residual error	4	1389436	347359		
Total	5	1651340			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	5265	2327	2.26	0.086
Distance (m)	45.99	52.96	0.87	0.434

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between distance and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between distance and force is important)

The regression equation is

Force (N) = 5265 + 45.99 distance (m)

y = 45.99 x +5265

From Minitab, the output state estimate model parameters smallest square is b_0 = 5265 and b_1 = 45.99.

P- value = 0.434

P- value > α = 0.05

Accept H_0.

Because the p-value is bigger than 0.05, we cannot reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-distance model is not important. Thus, we can conclude that there is no straight relationship between force and distance. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the distance is 0.87 and the p-value of 0.434. These important values below the regression tests showed that the distance does not contribute to the importance of regression to model.

4.6.4 Two steps without knee pad

For two steps without knee pad, the graph of Figure 4.12, Figure 4.13, and Figure 4.14 that had been analyzed were force versus velocity, force versus acceleration, and force versus distance.

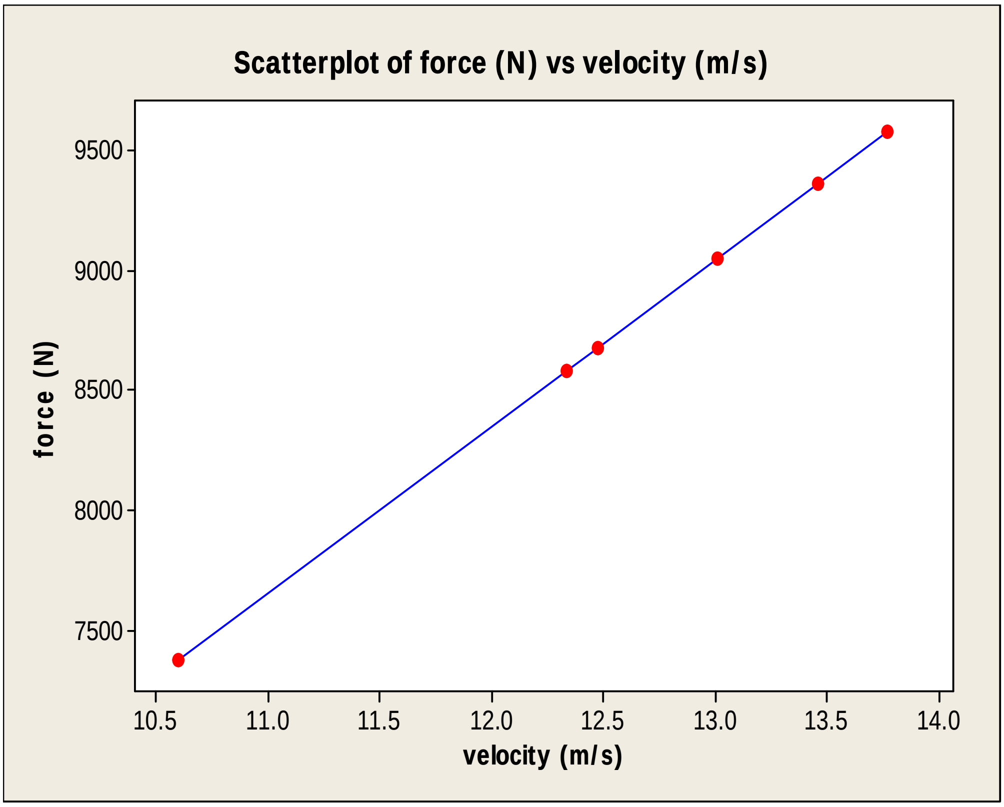


Figure 4.12: Graph of force versus velocity

Figure 4.12 shows a graph of force versus velocity for two steps and without using a knee pad. From the figure can show that the force is proportional to the velocity of the kick velocity which is the higher the velocity, the greater the force produced.

For the correlation analysis, correlation coefficient, r is 1.000 as in Table 4.15, which showed a high and strong relationship line between the amount of force as the dependent variable and velocity as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and velocity,

R^2 = 1.000 and output report R^2 x 100 % = 100 %. Regression model accounts for 100% state variable in the effort

Table 4.15: Correlation analysis, regression analysis, ANOVA, t-test (two steps without knee pad-force versus velocity)

Correlation analysis

		Force	**Velocity**
Force	Pearson Correlation	1	1.000(**)
	Sig. (2-tailed)		0.000
	N	6	6
Velocity	Pearson Correlation	1.000(**)	1
	Sig. (2-tailed)	0.000	
	N	6	6

** Correlation is significant at the 0.01 level (2-tailed)

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.00884

Predictors: (Constant), Velocity

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	3070550	3070550	3.92700E+10	0.000
Residual error	4	0	0		
Total	5	3070550			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	0.06548	0.04439	1.47	0.214
Velocity (m/s)	695.569	0.004	198166.50	0.000

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between velocity and force is not important)
$H_1 = \beta_1 \neq 0$ (the relationship between velocity and force is important)

The regression equation is
Force (N) = 0.06548 + 695.6 velocity (m/s)
y = 695.6 x +0.06548

From Minitab, the output state estimate model parameters smallest square is b_0 = 0.06548 and b_1 = 695.569.

P- Value = 0.000
P- Value $< \alpha = 0.05$

Reject H_0.

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-velocity model is important. Thus, we can conclude that there is a straight relationship between force and velocity. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the velocity is 198166.50 and the p-value of 0.000. These important values below the regression tests showed that the velocity of the importance of contributing to the model.

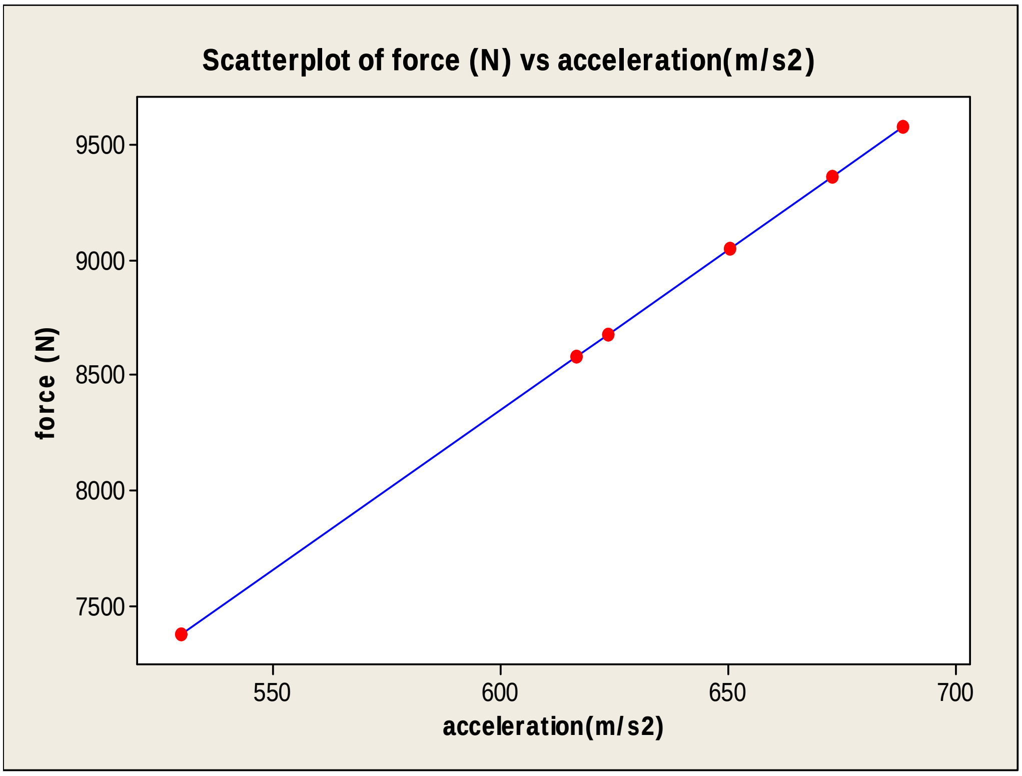


Figure 4.13: Graph of force versus acceleration

Figure 4.13 shows a graph of force versus acceleration for two steps and without using a knee pad. From the figure can show that the force is proportional to the acceleration which is the higher the acceleration, the greater the force produced.

For the correlation analysis, correlation coefficient, r is 1.000 as in Table 4.16, which showed a high and strong relationship line between the amount of force as the dependent variable and acceleration as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and acceleration, $R^2 = 1.000$ and output report $R^2 \times 100\ \% = 100\ \%$. Regression model accounts for 100% state variable in the effort.

Table 4.16: Correlation analysis, regression analysis, ANOVA, t-test (two steps without knee pad-force versus acceleration)

Correlation analysis

		Force	**Acceleration**
Force	Pearson Correlation	1	1.000(**)
	Sig. (2-tailed)		0.000
	N	6	6
Acceleration	Pearson Correlation	1.000(**)	1
	Sig. (2-tailed)	0.000	
	N	6	6

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.01885

Predictors: (Constant), acceleration

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	3070550	3070550	8.64414E+09	0.000
Residual error	4	0	0		
Total	5	3070550			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	-0.18413	0.09463	-1.95	0.124
Acceleration(m/s2)	13.9118	0.0001	92973.84	0.000

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between acceleration and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between acceleration and force is important)

The regression equation is

Force (N) = - 0.1841 + 13.91 acceleration (m/s2)

y = 13.91 x - 0.1841

From Minitab, the output state estimate model parameters smallest square is

b_0 = -0.18413   and b_1 = 13.9118.

P- Value = 0.000

P- Value $< \alpha$ = 0.05

Reject H_0.

Because the p-value is smaller than 0.05, we can reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-acceleration model is important. Thus, we can conclude that there is a straight relationship between force and acceleration. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the acceleration is 92973.84 and the p-value of 0.000. These important values below the regression tests showed that the acceleration of the importance of contributing to the model.

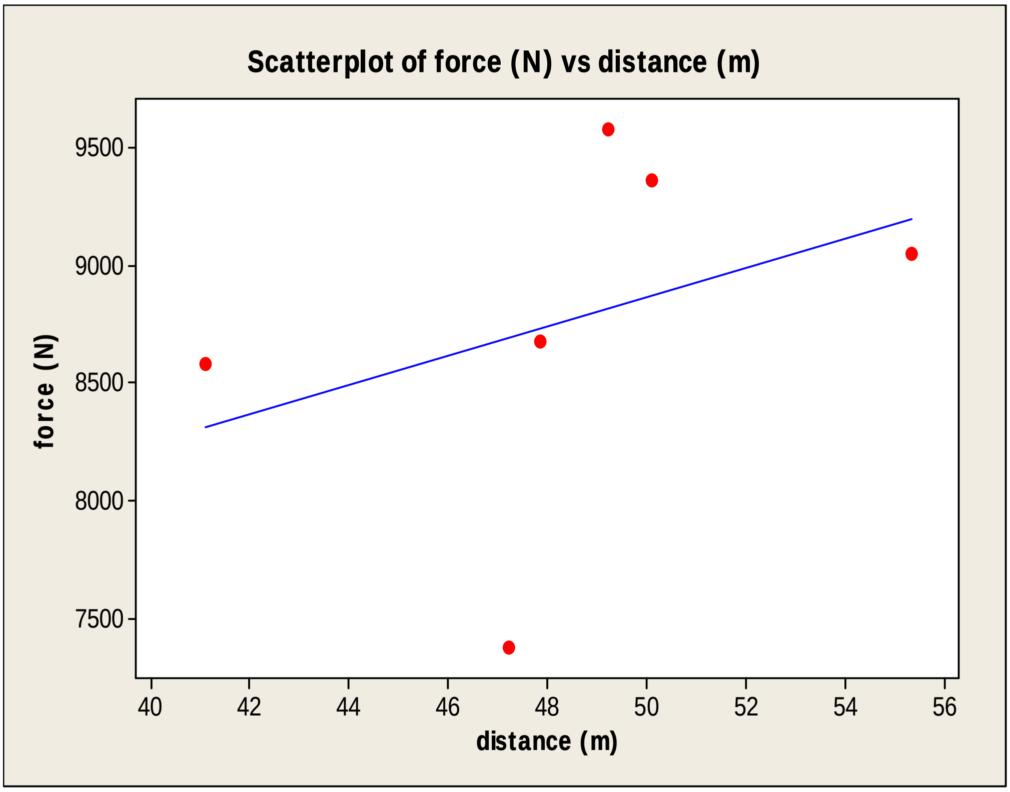


Figure 4.14: Graph of force versus distance

From the Figure 4.14 above of force versus distance graph, it shows the graph is plotted is not uniform and continuous. So this shows that these variables cannot be accepted and not significant.

For the correlation analysis, correlation coefficient, r is 0.369 as in Table 4.17, which showed a low relationship line between the amount of force as the dependent variable and distance as independent variables to the level of importance of 0.05 ($p < 0.05$). For the regression model for the force and distance, $R^2 = 0.136$ and output report $R^2 \times 100$ % = 13.6 %. Regression model accounts for 13.6 % state variable in the effort.

Table 4.17: Correlation analysis, regression analysis, ANOVA, t-test (two steps without knee pad-force versus distance)

Correlation analysis

		Force	**Distance**
Force	Pearson Correlation	1	0.369
	Sig. (2-tailed)		0.471
	N	6	6
Distance	Pearson Correlation	0.369	1
	Sig. (2-tailed)	0.471	
	N	6	6

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.369(a)	0.136	-0.080	814.26722

Predictors: (Constant), distance

ANOVA

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	418426	418426	0.63	0.471
Residual error	4	2652124	663031		
Total	5	3070550			

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	5733	3836	1.49	0.209
Distance (m)	62.64	78.85	0.79	0.471

Hypotheses are

$H_0 = \beta_1 = 0$ (the relationship between distance and force is not important)

$H_1 = \beta_1 \neq 0$ (the relationship between distance and force is important)

The regression equation is

Force (N) = 5733 + 62.64 distance (m)

y = 62.64 x +5733

From Minitab, the output state estimate model parameters smallest square is b_0 = 5733 and b_1 = 62.64.

P- Value = 0.471

P- Value > α = 0.05

Accept H_0.

Because the p-value is bigger than 0.05, we cannot reject H_0 at the critical level of 0.05. So, we have strong evidence that the force-distance model is not important. Thus, we can conclude that there is no straight relationship between force and distance. A t-test was conducted to determine the importance of regression coefficients, b_1. For the t-value, the value of the distance is 0.79 and the p-value of 0.471. These important values below the regression tests showed that the distance does not contribute to the importance of regression to model.

4.6.5 Correlation analysis discussion

Correlation analysis in the table to assess the relationship between the models with each variable force, velocity, acceleration and distance when kicked. Objective of this analysis is to identify the variables that have the most dominant relations of power model.

Table 4.18: Correlation table of one step with knee pad

Parameter	Correlation	Value
Variable velocity with a force model	Pearson correlation	0.98(**)
	Sig. (2-tailed)	0.001
Variable acceleration with a force model	Pearson correlation	0.798
	Sig. (2-tailed)	0.013
Variable distance during a kick with the force model	Pearson correlation	0.077
	Sig. (2-tailed)	0.608

** Correlation is significant at the 0.01 level (2-tailed).

From Table 4.18, velocity and acceleration showed highest value which near to 1.00 which means the highest and strongest correlation. They are 0.98 and 0.798. Distance showed the weakest relationship of correlation to the force model.

Table 4.19: Correlation table of one step without knee pad

Parameter	Correlation	Value
Variable velocity with a force model	Pearson correlation	1.00(**)
	Sig. (2-tailed)	0.00
Variable acceleration with a force model	Pearson correlation	1.00(**)
	Sig. (2-tailed)	0.00
Variable distance during a kick with the force model	Pearson correlation	0.18
	Sig. (2-tailed)	0.732

** Correlation is significant at the 0.01 level (2-tailed).

From Table 4.19, velocity and acceleration showed highest value which is 1.00 that means the highest and strongest correlation. Distance showed the weakest relationship of correlation to the force model where it is 0.18.

Table 4.20: Correlation table of two steps with knee pad

Parameter	Correlation	Value
Variable velocity with a force model	Pearson correlation	1.00(**)
	Sig. (2-tailed)	0.00
Variable acceleration with a force model	Pearson correlation	1.00(**)
	Sig. (2-tailed)	0.00
Variable distance during a kick with the force model	Pearson correlation	0.398
	Sig. (2-tailed)	0.434

** Correlation is significant at the 0.01 level (2-tailed).

From Table 4.20, velocity and acceleration showed highest value which is 1.00 that means the highest and strongest correlation. Distance showed the lowest relationship of correlation to the force model where it is 0.398.

Table 4.21: Correlation table of two steps without knee pad

Parameter	Correlation	Value
Variable velocity with a force model	Pearson correlation	1.00(**)
	Sig. (2-tailed)	0.00
Variable acceleration with a force model	Pearson correlation	1.00(**)
	Sig. (2-tailed)	0.00
Variable distance during a kick with the force model	Pearson correlation	0.369
	Sig. (2-tailed)	0.471

** Correlation is significant at the 0.01 level (2-tailed).

From Table 4.21, velocity and acceleration showed highest value which is 1.00 that means the highest and strongest correlation. Distance showed the lowest relationship of correlation to the force model where it is 0.369.

Based on correlation Pearson Table 4.18, Table 4.19, Table 4.20 and Table 4.21, they showed that velocity and acceleration is significant at the 0.01 level (2-

tailed). It can be proved with significant correlation range that 0.00 no correlation, 0.01-0.30 weak correlation, 0.30-0.50 low correlation, 0.50-0.70 average correlation, 0.70-0.90 high correlation and 0.90-1.00 is high and strong correlation. From the correlation value above, it concluded that velocity and acceleration are in the high and strong correlation. It means that both of them have high significant value to the model.

4.7 MULTI LINEAR REGRESSION

Multi linear regression consists of analysis for one step with knee pad, one step without knee pad, two steps with knee pad and two steps without knee pad.

4.7.1 One step with knee pad

For instep on one step and with knee pad, force, velocity, acceleration and distance between frames were involved. They were indicated as in Table 4.22.

Table 4.22: Force, velocity, acceleration and distance between frames

Frame	Force, N	Velocity, m/s	Acceleration, m/s2	Distance between frame
1	0	0	0	0
2	5838.66	8.394	101.41	0.148
3	7910.77	11.373	196.528	0.188
4	8869.97	12.752	-58.621	0.267
5	7745.92	11.136	-103.02	0.243
6	6319.99	9.086	-101.97	0.202
7	5005.36	7.196	-87.031	0.161
8	0	0	0	0.127

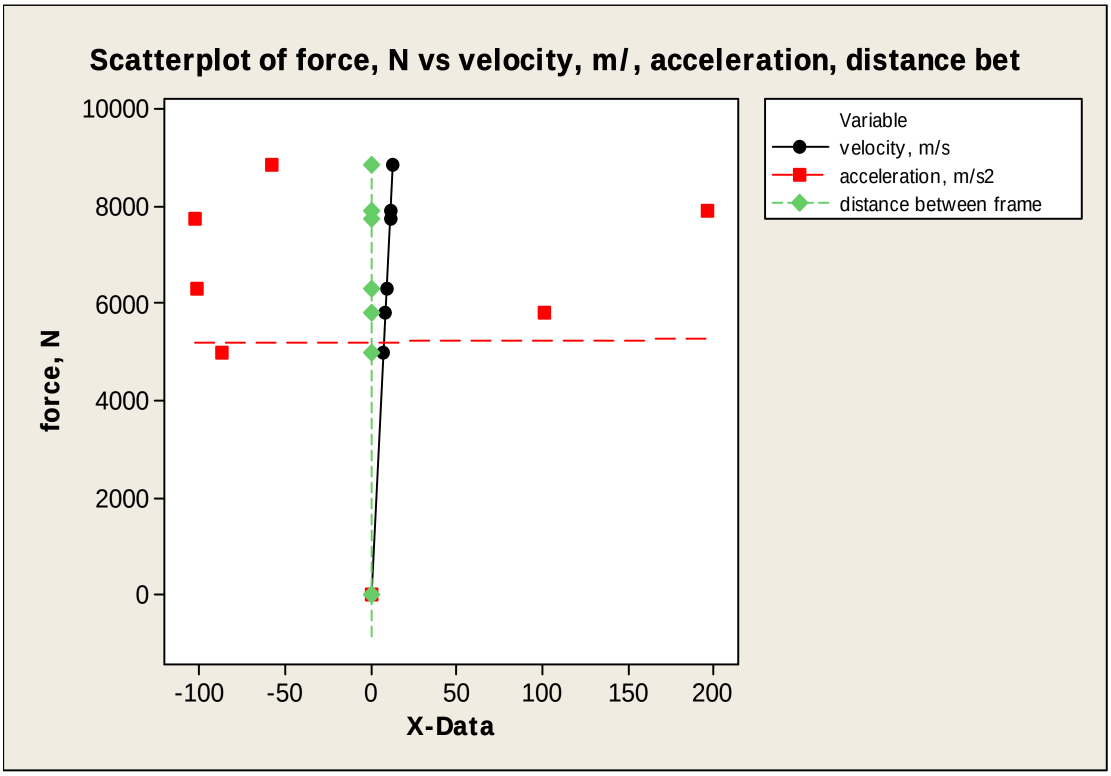


Figure 4.15: Graph of force versus velocity, acceleration and distance between frames

Direction of the velocity and distance are different from relations with the rate of acceleration forces. Figure 4.15 shows the uneven distribution and lack of a straight relationship between force and acceleration.

In straight multiple regression model, it is customary to refer to R^2 as determining the gain coefficient. For its rate regression model, R^2 = 1.00 and output report R^2 x 100 % = 100 %. This can be interpreted using the model equation can, in which about 100 % can be interpreted change in the amount of force. So it means that the variables in the model are able to interpret the force at 100 % accuracy.

Table 4.23: Correlation analysis, regression analysis, ANOVA, t-test

Correlation analysis

		Force	**Velocity**	**Acceleration**	**Distance between frame**
Force	Pearson Correlation	1	1.000(**)	0.009	0.868(**)
	Sig. (2-tailed)		0.000	0.983	0.005
	N	8	8	8	8
Velocity	Pearson Correlation	1.000(**)	1	0.009	0.868(**)
	Sig. (2-tailed)	0.000		0.983	0.005
	N	8	8	8	8
Acceleration	Pearson Correlation	0.009	0.009	1	-0.235
	Sig. (2-tailed)	0.983	0.983		0.575
	N	8	8	8	8
Distance between frame	Pearson Correlation	0.868(**)	0.868(**)	-0.235	1
	Sig. (2-tailed)	0.005	0.005	0.575	
	N	8	8	8	8

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.00350

Predictors: (Constant), velocity, acceleration, distance between frame

ANOVAs

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	3	83077784	27692595	2.25690E+12	0.000
Residual Error	4	0	0		
Total	7	83077784			

Table 4.23: Continued

t- Test

Predictor	Coef	SE Coef	T	P
Constant	0.001702	0.003185	0.53	0.621
Velocity, m/s	695.575	0.001	1156511.32	0.000
Acceleration, m/s2	-0.00000067	0.00001416	-0.05	0.964
Distance between frame	-0.01329	0.03727	-0.36	0.739

Equation model to be used is $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_{3.}$ The regression equation is:

Force, N = 0.00170 + 696 velocity, m/s - 0.000001 acceleration, m/s2- 0.0133 distance between frame

So, $y = 0.00170 + 696\ x_1 - 0.000001\ x_2 - 0.0133\ x_3$
Where, y equal to force and x equal to velocity, acceleration and distance.

Hypothesis test is done to determine the relationship between the amount of force (y), velocity (x_1), acceleration (x_2), and also the distance (x_3). The least squares point estimates for model parameters is $\beta_0 = 0.00170$, $\beta_1 = 696$, $\beta_2 = -0.000001$, and $\beta_3 = -0.0133$.

The hypotheses are:

$H_0 : \beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (no relationship between the amount of force and velocity, acceleration and distance)
H_1 : at least one of β_0, β_1, β_2, β_3 will not be equal to 0 in the population. (The possibility of a link between the amount of force with velocity, acceleration and distance in population)

The regression analysis, ANOVA and t-test are as in table before

The hypothesis is:

H_0 : $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (the relationship between velocity, acceleration and distance and the amount of force is not important)
H_1 : at least $\beta_j \neq 0$ (the relationship between velocity, acceleration and distance and the amount of force is important)

P- value : 0.000
P- value $< \alpha = 0.05$

Reject H_0.

When the P- value is less than 0.05, we can reject H_0. Therefore, we can prove that the strong force model is a significant predictor. Conclusion can be made that there is at least the one random variable, velocity, acceleration and distance of the model is significantly related to the amount of force.

For the t-test, the velocity, t_1 = 1156511.32 has a value of p is 0.000, which indicates that the velocity is significant to the model. While the value of t for acceleration, t_2 = -0.05, the P-value is 0.964 and the distance, t_3 =-0.36 has a P-value of 0.739 which show that the velocity is not significant to the model.

4.7.2 Two step with knee pad

For instep kick on two steps and with knee pad, force, velocity, acceleration and distance between frames were involved. They were indicated as in Table 4.24.

Table 4.24: Force, velocity, acceleration and distance between frames

Frame	Force, N	Velocity, m/s	Acceleration, m/s2	Distance between frame
1	0	0	0	0
2	5975.68	8.591	153.349	0.141
3	8125.71	11.682	155.764	0.202
4	8690.51	12.494	-74.567	0.265
5	7754.27	11.148	-60.011	0.235
6	6214.96	8.935	-161.28	0.211
7	4231.88	6.084	-123.81	0.146
8	0	0	0	0.097

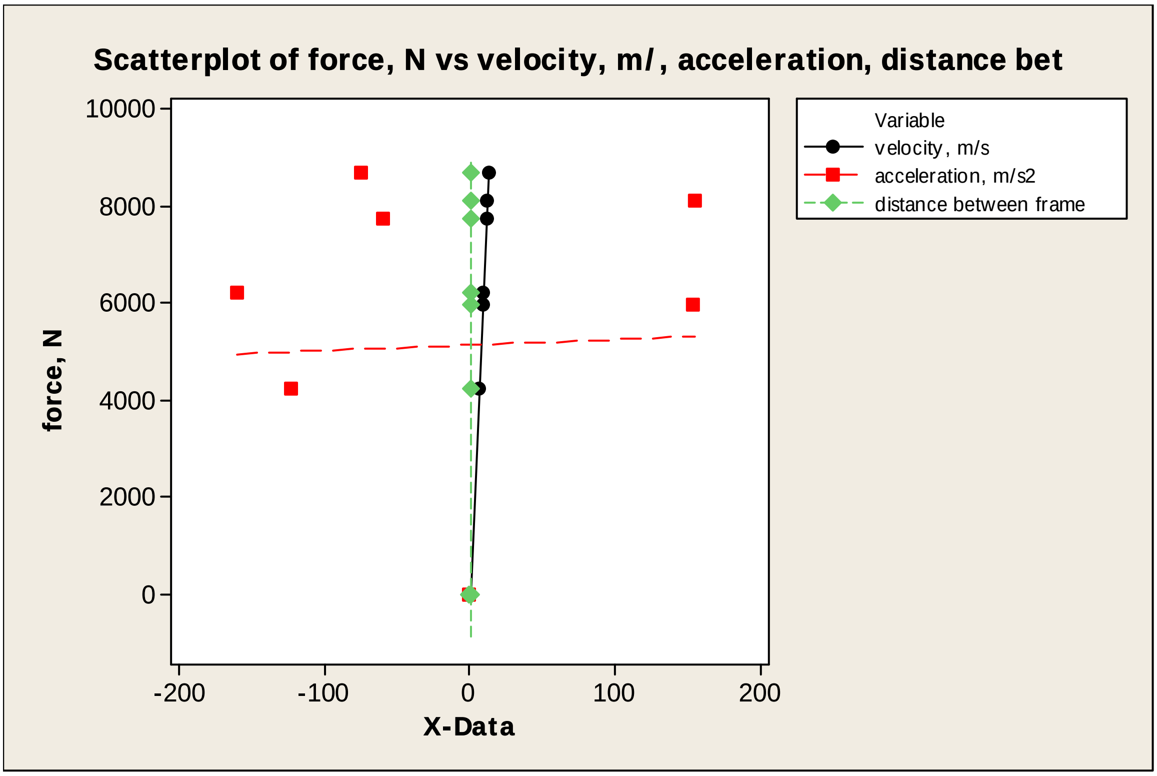


Figure 4.16: Graph of force versus velocity, acceleration, and distance between frames

Direction of the velocity and distance are different from relations with the rate of acceleration forces. Figure 4.16 shows the uneven distribution and lack of a straight relationship between force and acceleration.

Table 4.25: Correlation analysis, regression analysis, ANOVA, t-test

Correlation analysis

		Force	Velocity	Acceleration	Distance between frame
Force	Pearson Correlation	1	1.000(**)	0.038	0.914(**)
	Sig. (2-tailed)		0.000	0.928	0.001
	N	8	8	8	8
Velocity	Pearson Correlation	1.000(**)	1	0.038	0.914(**)
	Sig. (2-tailed)	0.000		0.928	0.001
	N	8	8	8	8
Acceleration	Pearson Correlation	0.038	.038	1	-0.213
	Sig. (2-tailed)	0.928	.928		0.613
	N	8	8	8	8
Distance between frame	Pearson Correlation	0.914(**)	0.914(**)	-0.213	1
	Sig. (2-tailed)	0.001	0.001	0.613	
	N	8	8	8	8

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000(a)	1.000	1.000	0.00349

Predictors: (Constant), velocity, acceleration, distance between frames

ANOVAs

Source	DF	SS	MS	F	P
Regression	3	83870759	27956920	2.30121E+12	0.000
Residual Error	4	0	0		
Total	7	83870759			

Table 4.25: Continued

t- Test

Predictor	**Coef**	**SE Coef**	**T**	**P**
Constant	0.000104	0.003099	0.03	0.975
Velocity, m/s	695.575	0.001	862520.18	0.000
Acceleration, m/s2	0.00000127	0.00001417	0.09	0.933
Distance between frame	-0.00139	0.04803	-0.03	0.978

In straight multiple regression model, it is customary to refer to R^2 as determining the gain coefficient. For its rate regression model, $R^2 = 1.00$ and output report R^2 x 100% = 100%. This can be interpreted using the model equation can, in which about 100% can be interpreted change in the amount of force. So it means that the variables in the model are able to interpret the force at 100% accuracy.

Equation model to be used is $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$. The regression equation is:

Force, N = 0.00010 + 696 velocity, m/s + 0.000001 acceleration, m/s2 - 0.0014 distance between frame

So, $y = 0.00010 + 696\ x_1 + 0.000001\ x_2 - 0.0014\ x_3$

Where, y equal to force and x equal to velocity, acceleration and distance.

Hypothesis test is done to determine the relationship between the amount of force (y), velocity (x_1), acceleration (x_2), and also the distance (x_3). The least squares point estimates for model parameters is $\beta_0 = 0.00010$, $\beta_1 = 696$, $\beta_2 = 0.000001$, and $\beta_3 = -0.0014$.

The hypothesis is:

H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (no relationship between the amount of force and velocity, acceleration and distance)

H_1: at least one of β_0, β_1, β_2, β_3 will not be equal to 0 in the population. (The possibility of a link between the amount of force with velocity, acceleration and distance in population)

The regression analysis, ANOVA and t-test are as in table before.
The hypothesis is:

H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (the relationship between velocity, acceleration and distance and the amount of force is not important)
H_1: at least $\beta_j \neq 0$ (the relationship between velocity, acceleration and distance and the amount of force is important)

P- value: 0.000
P- Value $< \alpha = 0.05$

Reject H_0.

When the P- value is less than 0.05, we can reject H_0. Therefore, we can prove that the strong force model is a significant predictor. Conclusion can be made that there is at least the one random variable, velocity, acceleration and distance of the model is significantly related to the amount of force.

For the t-test, the velocity, $t_1 = 862520.18$ has a value of p is 0.000, which indicates that the velocity is significant to the model. While the value of t for acceleration, $t_2 = 0.09$, the P-value is 0.933 and the distance, $t_3 = -0.03$ has a P-value of 0.978 which show that the velocity is not significant to the model.

4.7.3 One step without knee pad

For instep kick on one step and without knee pad, force, velocity, acceleration and distance between frames were involved. They were indicated as in Table 4.26.

Table 4.26: Force, velocity, acceleration and distance between frames

Frame	Force, N	Velocity, m/s	Acceleration, m/s2	Distance between frame
1	0	0	0	0
2	4165.8	5.989	142.682	0.091
3	6050.11	8.698	128.207	0.148
4	8335.08	11.983	200.356	0.2
5	8518.01	12.246	-174.08	0.28
6	6956.45	10.001	-50.396	0.21
7	5458.18	7.847	-165.07	0.19
8	0	0	0	0.124

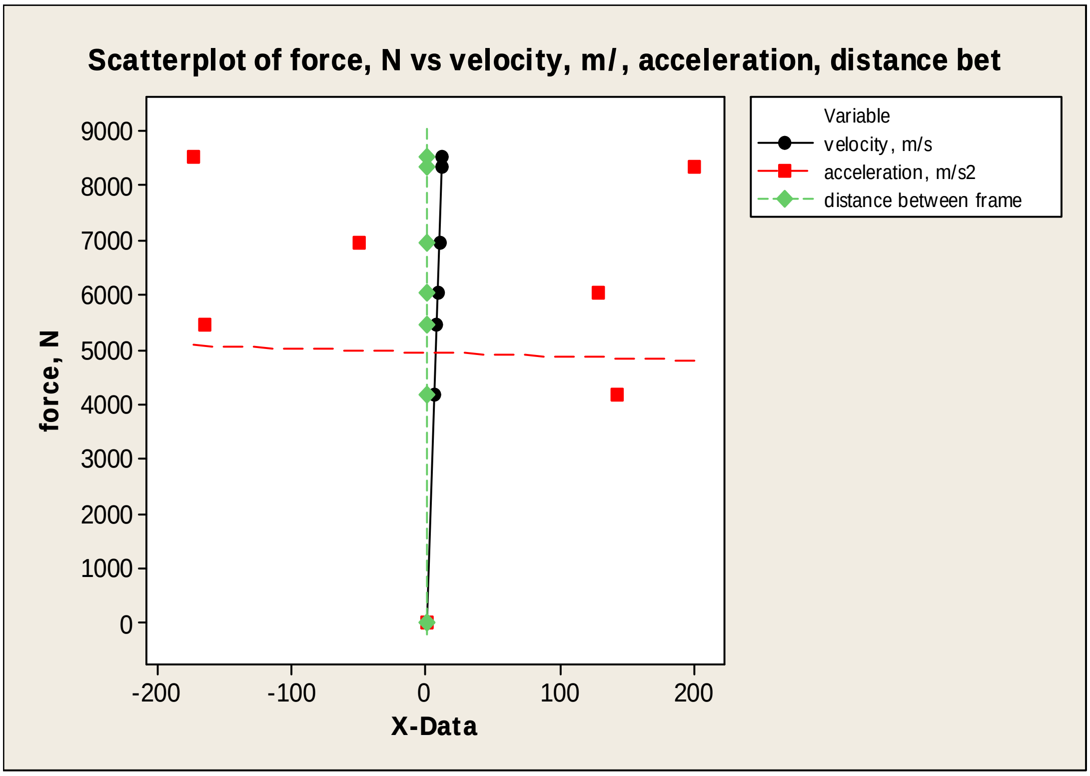


Figure 4.17: Graph of force versus velocity, acceleration and distance between frames

Direction of the velocity and distance are different from relations with the rate of acceleration forces. Figure 4.17 shows the uneven distribution and lack of a straight relationship between force and acceleration.

Table 4.27: Correlation analysis, regression analysis, ANOVA, t-test

Correlation analysis

		Force	**Velocity**	**Acceleration**	**Distance between frame**
Force	Pearson Correlation	1	1.000(**)	-0.030	0.840(**)
	Sig. (2-tailed)		0.000	0.944	0.009
	N	8	8	8	8
Velocity	Pearson Correlation	1.000(**)	1	-0.030	0.840(**)
	Sig. (2-tailed)	0.000		0.944	0.009
	N	8	8	8	8
Acceleration	Pearson Correlation	-0.030	-0.030	1	-0.376
	Sig. (2-tailed)	0.944	0.944		0.359
	N	8	8	8	8
Distance between frame	Pearson Correlation	0.840(**)	0.840(**)	-0.376	1
	Sig. (2-tailed)	0.009	0.009	0.359	
	N	8	8	8	8

** Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.00303

Predictors: (Constant), velocity, acceleration, distance between frame

ANOVAs

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	3	79302069	26434023	2.88117E+12	0.000
Residual Error	4	0	0		
Total	7	79302069			

Table 4.27: Continued

t- Test

Predictor	Coef	SE Coef	T	P
Constant	0.000176	0.002649	0.07	0.950
Velocity, m/s	695.575	0.001	1311730.50	0.000
Acceleration, m/s2	0.00000283	0.00001077	0.26	0.806
Distance between frame	-0.00136	0.03242	-0.04	0.969

In straight multiple regression model, it is customary to refer to R^2 as determining the gain coefficient. For its rate regression model, $R^2 = 1.00$ and output report R^2 x 100% = 100%. This can be interpreted using the model equation can, in which about 100% can be interpreted change in the amount of force. So it means that the variables in the model are able to interpret the force at 100% accuracy.

Equation model to be used is $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$. The regression equation is:

Force, N = 0.00018 + 696 velocity, m/s + 0.000003 acceleration, m/s2
- 0.0014 distance between frame

So, $y = 0.00018 + 696\, x_1 + 0.000003\, x_2 - 0.0014\, x_3$
Where, y equal to force and x equal to velocity, acceleration and distance.

Hypothesis test is done to determine the relationship between the amount of force (y), velocity (x_1), acceleration (x_2), and also the distance (x_3). The least squares point estimates for model parameters is $\beta_0 = 0.00018$, $\beta_1 = 696$, $\beta_2 = 0.000003$, and $\beta_3 = -0.0014$.

The hypothesis is:

H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (no relationship between the amount of force and velocity, acceleration and distance)
H_1: at least one of β_0, β_1, β_2, β_3 will not be equal to 0 in the population. (The possibility of a link between the amount of force with velocity, acceleration and distance in population)

The regression analysis, ANOVA and t-test are as in table before.

The hypothesis is:

H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (the relationship between velocity, acceleration and distance and the amount of force is not important)
H_1: at least $\beta_j \neq 0$ (the relationship between velocity, acceleration and distance and the amount of force is important)

P- value: 0.000
P- Value $< \alpha = 0.05$

Reject H_0.

When the P- value is less than 0.05, we can reject H_0. Therefore, we can prove that the strong force model is a significant predictor. Conclusion can be made that there is at least the one random variable, velocity, acceleration and distance of the model is significantly related to the amount of force.

For the t-test, the velocity, t_1 = 1311730.50has a value of p is 0.000, which indicates that the velocity is significant to the model. While the value of t for acceleration, t_2 = 0.26, the P-value is 0.806 and the distance, t_3 = -0.04 has a P-value of 0.969 which show that the velocity is not significant to the model.

4.7.4 Two step without knee pad

For instep kick on two steps and without knee pad, force, velocity, acceleration and distance between frames were involved. They were indicated as in Table 4.28.

Table 4.28: Force, velocity, acceleration and distance between frames

Frame	Force, N	Velocity, m/s	Acceleration, m/s2	Distance between frame
1	0	0	0	0
2	4336.21	6.234	20.049	0.121
3	6227.48	8.953	251.915	0.129
4	9511.29	13.674	220.086	0.229
5	10083.06	14.496	-137.88	0.317
6	7909.38	11.371	-174.57	0.262
7	6591.96	9.477	-14.837	0.193
8	0	0	0	0.187

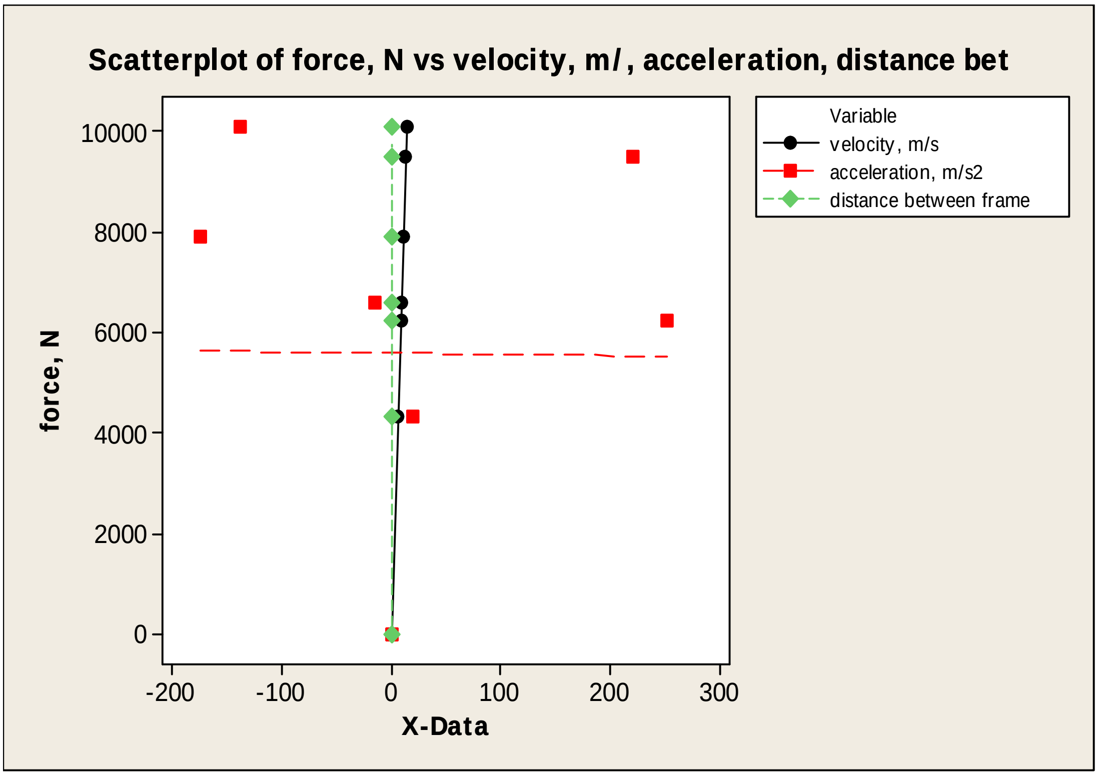


Figure 4.18: Graph of force versus velocity, acceleration and distance between frames

Direction of the velocity and distance are different from relations with the rate of acceleration forces. Figure 4.18 shows the uneven distribution and lack of a straight relationship between force and acceleration.

Table 4.29: Correlation analysis, regression analysis, ANOVA, t-test

Correlation analysis

		Force	**Velocity**	**Acceleration**	**Distance between frame**
Force	Pearson Correlation	1	1.000(**)	-0.010	0.759(*)
	Sig. (2-tailed)		0.000	0.982	0.029
	N	8	8	8	8
Velocity	Pearson Correlation	1.000(**)	1	-0.010	0.759(*)
	Sig. (2-tailed)	0.000		0.982	0.029
	N	8	8	8	8
Acceleration	Pearson Correlation	-0.010	-0.010	1	-0.356
	Sig. (2-tailed)	0.982	0.982		0.387
	N	8	8	8	8
Distance between frame	Pearson Correlation	0.759(*)	0.759(*)	-0.356	1
	Sig. (2-tailed)	0.029	0.029	0.387	
	N	8	8	8	8

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Regression analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000(a)	1.000	1.000	0.00370

Predictors: (Constant), velocity, acceleration, distance between frame

Table 4.29: Continued

ANOVAs

Source	DF	SS	MS	F	P
Regression	3	106421662	35473887	2.58920E+12	0.000
Residual Error	4	0	0		
Total	7	106421662			

t- Test

Predictor	Coef	SE Coef	T	P
Constant	-0.002784	0.003163	-0.88	0.428
Velocity, m/s	695.575	0.000	1641352.82	0.000
Acceleration, m/s2	-0.00000393	0.00001100	-0.36	0.739
Distance between frame	0.01479	0.02606	0.57	0.601

In straight multiple regression model, it is customary to refer to R^2 as determining the gain coefficient. For its rate regression model, $R^2 = 1.00$ and output report R^2 x 100% = 100%. This can be interpreted using the model equation can, in which about 100% can be interpreted change in the amount of force. So it means that the variables in the model are able to interpret the force at 100% accuracy.

Equation model to be used is $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$. The regression equation is:

Force, N = - 0.00278 + 696 velocity, m/s - 0.000004 acceleration, m/s2 + 0.0148 distance between frame

So, $y = - 0.00278 + 696\, x_1 - 0.000004\, x_2 + 0.0148\, x_3$

Where, y equal to force and x equal to velocity, acceleration and distance.

Hypothesis test is done to determine the relationship between the amount of force (y), velocity (x_1), acceleration (x_2), and also the distance (x_3). The least squares point estimates for model parameters is $\beta_0 = -0.00278$, $\beta_1 = 696$, $\beta_2 = -0.000004$, and $\beta_3 = 0.0148$.

The hypothesis is:

H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (no relationship between the amount of force and velocity, acceleration and distance)
H_1: at least one of β_0, β_1, β_2, β_3 will not be equal to 0 in the population. (The possibility of a link between the amount of force with velocity, acceleration and distance in population)

The regression analysis, ANOVA and t-test are as in table before.

The hypothesis is:

H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (the relationship between velocity, acceleration and distance and the amount of force is not important)
H_1: at least $\beta_j \neq 0$ (the relationship between velocity, acceleration and distance and the amount of force is important)

P- value: 0.000
P- Value $< \alpha = 0.05$

Reject H_0.

When the P- value is less than 0.05, we can reject H_0. Therefore, we can prove that the strong force model is a significant predictor. Conclusion can be made that there is at least the one random variable, velocity, acceleration and distance of the model is significantly related to the amount of force.

For the t-test, the velocity, t_1 = 1641352.82 has a value of p is 0.000, which indicates that the velocity is significant to the model. While the value of t for acceleration, t_2 = -0.36, the P-value is 0.739 and the distance, t_3 = 0.57 has a P-value of 0.601 which show that the velocity is not significant to the model.

4.8 PERCEPTION ANALYSIS

A set of well structured survey questionnaires was developed. The survey consists of two sections which were:

i. Introduction of subject and anthropometric data,
ii. Perception on knee pad involvement in kicking performance

Likert Scale with five perceptions of opinions has been adopted in this survey questionnaire. Subjects need to select their perception based on the 1 to 4 of scale which were varies from totally disagree (1), disagree (2), not sure (3), agree (4), totally agree (5). The questionnaire is used to evaluate the perception of subjects based on the needed of using knee pad in football games. The results from survey questionnaires were analyzed by using SPSS 15.0.

From the first sections, the subject anthropometric data and the other basics question regarding their training period and life as football player had been asked and the details are as in table below

Table 4.30: Characteristics of the sample

Characteristics	Category	Percentage (%)
Gender	Male	100
	Female	0
Age	<20	100
	21-25	0
	26-30	0
Height	160-164	16.7
	165-169	25
	170-174	16.7
	175-179	25
	180-184	16.7

Table 4.30: Continued

Characteristics	**Category**	**Percentage (%)**
Weight	45-50	16.7
	50-59	16.7
	60-69	41.7
	70-79	25
	80-89	0
Football involvement period	< 1 year	0
	1 to 2	0
	3 to 5	25
	>6	75
Past injury	Yes	8.3
	No	91.7
Position	Striker	8.3
	Goalkeeper	33.3
	Middle player	41.7
	Defender	16.7
	Other	0
Health	Excellent	16.7
	Very good	33.3
	Good	41.7
	Fair	8.3
	Poor	0
Past operation	Yes	0
	No	100
Preferred leg	Right	100
	Left	0
Preferred football shoes	Nike	58.3
	Adidas	16.7
	Asics	8.3
	Lotto	0
	Other (Puma)	16.7
Training per week	1 to 2 days	0
	3 to 4 days	0
	>5	100
Hour per training	< 1	0
	1 to 2 hours	58.3
	>2	41.7

As in the Table 4.30, 100 % of the subjects are male with age under 20 years old. All of them are in the range of height 160 cm to 184 cm and weight of 45 kg to 79 kg. 16.7 % are at the range of 160 cm to 164 cm, 25 % at the range of 165 cm to

169 cm, 16.7 % at 170 cm to 174 cm, 25 % at the range of 175 cm to 179 cm and 16.7 % at the range of 180 cm to 184 cm. For weight of below 50 kg, there are 16.7 % and same goes to weight of 50 kg to 59 kg while there are 41.7 % subject for weight of 60 kg to 69 kg and 25 % of weight 70 kg to 79 kg. all of the subjects involve had experience in football games for more than three years and most of them, (91.7 %) did not have any injuries for past days, weeks or months before rather than few of them that had injury before which is knee injury. However, they can play well when joining this study since the injury heals enough. There are 8.3 % of them who are striker, 33.3 % of them who are goalkeeper, 41.7 % middle player, and 16.7 % defender. All of them are made sure in a healthy condition as they join this study and none of them had undergone any operation before. 100 % of them preferred right leg as dominant limb and had training more than five hours per week with more than one hour per training. 58.3 % of them preferred Nike brand shoes for football games, 16.7 % preferred Adidas brand shoes, 8.3 % for Asics brand, and 16.7 % more to Puma brand shoes. It depends on their comfort towards shoes brand design.

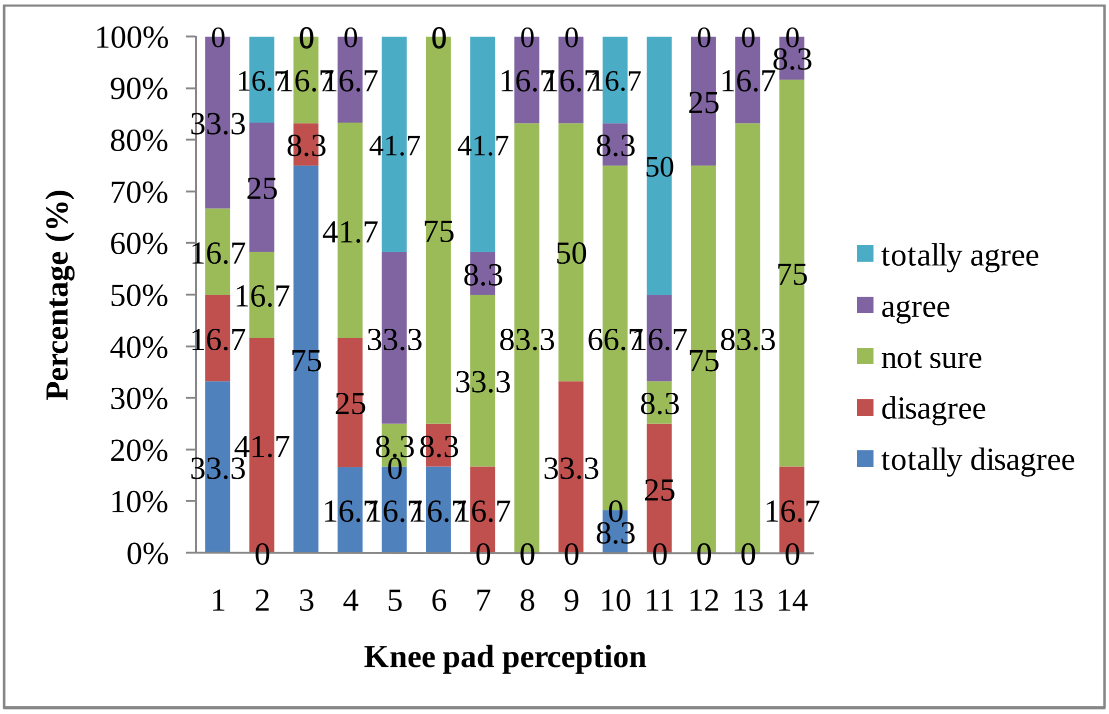


Figure 4.19: Likert scale analysis on knee pad perception

For this Likert Scale, which is in second section, it showed in the bar graph in Figure 4.19 above based on their knee pad perception for every question that had been asked to them. There are 14 question survey involved as in Appendix A1.

From Figure 4.19, analysis made on knee pad showed that 33.3 % of the subject agree that knee pad is comfortable to wear and there are also same value, (33.3 %) that are totally disagree that knee pad is comfortable to wear. 16.7 % of them are not sure and disagree. 41.7 % of the subject disagree that using knee pad will affect kicking technique. However, there are 16.7 % of them who are not sure, 25 % who agree and 16.7 % who totally agree. For the third question, 75 % of the subjects totally disagree of not frequently using knee pad since in Malaysia; knee pad is not recommended by the coach to be used by the player. As many as 41.7 % not sure if using knee pad will make it hard to move the leg and 25 % are disagree with the statement since they feel comfortable with it. 16.7 % are totally disagreed and 16.7 % are also agreed.

For perception on maximum protection that knee pad give to the knee, 41.7 % are totally agree and 33.3 % agree with it. There are 8.3 % who not sure and 16.7 % who totally disagree. 75 % of the subject did not sure if knee pad can improve kicking speed itself while 16.7 % totally disagree and 8.3% are disagree. Apart from that, 41.7 % totally agree and 8.3 % agree that knee pad is one of main equipment in football games for player. 33.3 % are not sure and 16.7 % are disagreed with that. 83.3 % not sure if knee pad can lead to better performance in football games while 16.7 % are agreed. For ninth and tenth question, most of them, (more than 50 %) are not sure if knee pad will increase or decrease the ball velocity.

50 % of the subjects totally agree and 16.7 % agree that knee pad give more flexibility to their leg movement. However 25 % are disagreed and 8.3 % are not sure. In addition, 75 % are not sure if accuracy of kicking and force towards the ball can increase by using knee pad while 83.3 % also not sure if ball distance may increase when using knee pad.

Table 4.31: Correlation

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1	Pearson Correlation	1	-0.230	0.521	0.265	-0.203	-0.030	-0.923(*)	-0.026	-0.044	-0.224	-0.830	0.047	-0.026	-0.110
	Sig. (2-tailed)		0.710	0.368	0.666	0.743	0.961	0.025	0.967	0.944	0.718	0.082	0.940	0.967	0.861
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q2	Pearson Correlation	-0.230	1	-0.721	0.166	-0.319	-0.211	0.147	-0.088	0.486	-0.248	0.371	-0.063	-0.088	0.081
	Sig. (2-tailed)	0.710		0.169	0.790	0.600	0.733	0.813	0.888	0.407	0.688	0.538	0.920	0.888	0.897
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q3	Pearson Correlation	0.521	-0.721	1	0.081	-0.279	0.144	-0.599	-0.134	-0.324	-0.078	-0.684	-0.182	-0.134	-0.153
	Sig. (2-tailed)	0.368	0.169		0.897	0.649	0.817	0.286	0.830	0.594	0.901	0.203	0.770	0.830	0.806
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q4	Pearson Correlation	0.265	0.166	0.081	1	-0.784	0.844	-0.055	0.800	0.907(*)	0.652	-0.647	0.781	0.800	0.881(*)
	Sig. (2-tailed)	0.666	0.790	0.897		0.117	0.072	0.930	0.104	0.033	0.234	0.238	0.119	0.104	0.049
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 4.31: Continued

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q5	Pearson Correlation	-0.203	-0.319	-0.279	-0.784	1	-0.504	0.244	-0.301	-0.685	-0.181	0.535	-0.242	-0.301	-0.505
	Sig. (2-tailed)	0.743	0.600	0.649	0.117		0.386	0.692	0.622	0.202	0.771	0.353	0.695	0.622	0.385
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q6	Pearson Correlation	-0.030	-0.211	0.144	0.844	-0.504	1	0.292	0.933(*)	0.740	0.931(*)	-0.484	0.882(*)	0.933(*)	0.947(*)
	Sig. (2-tailed)	0.961	0.733	0.817	0.072	0.386		0.634	0.021	0.153	0.022	0.409	0.048	0.021	0.014
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q7	Pearson Correlation	-0.923(*)	0.147	-0.599	-0.055	0.244	0.292	1	0.365	0.239	0.533	0.691	0.313	0.365	0.388
	Sig. (2-tailed)	0.025	0.813	0.286	0.930	0.692	0.634		0.545	0.698	0.355	0.196	0.608	0.545	0.519
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q8	Pearson Correlation	-0.026	-0.088	-0.134	0.800	-0.301	0.933(*)	0.365	1	0.779	0.956(*)	-0.371	0.991(**)	1.000(**)	0.963(**)
	Sig. (2-tailed)	0.967	0.888	0.830	0.104	0.622	0.021	0.545		0.121	0.011	0.538	0.001	0.000	0.008
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q9	Pearson Correlation	-0.044	0.486	-0.324	0.907(*)	-0.685	0.740	0.239	0.779	1	0.634	-0.284	0.765	0.779	0.893(*)
	Sig. (2-tailed)	0.944	0.407	0.594	0.033	0.202	0.153	0.698	0.121		0.251	0.643	0.132	0.121	0.042
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 4.31: Continued

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q10	Pearson Correlation	-0.224	-0.248	-0.078	0.652	-0.181	0.931(*)	0.533	0.956(*)	0.634	1	-0.230	0.920(*)	0.956(*)	0.910(*)
	Sig. (2-tailed)	0.718	0.688	0.901	0.234	0.771	0.022	0.355	0.011	0.251		0.710	0.027	0.011	0.032
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q11	Pearson Correlation	-0.830	0.371	-0.684	-0.647	0.535	-0.484	0.691	-0.371	-0.284	-0.230	1	-0.384	-0.371	-0.340
	Sig. (2-tailed)	0.082	0.538	0.203	0.238	0.353	0.409	0.196	0.538	0.643	0.710		0.524	0.538	0.576
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q12	Pearson Correlation	0.047	-0.063	-0.182	0.781	-0.242	0.882(*)	0.313	0.991(**)	0.765	0.920(*)	-0.384	1	0.991(**)	0.933(*)
	Sig. (2-tailed)	0.940	0.920	0.770	0.119	0.695	0.048	0.608	0.001	0.132	0.027	0.524		0.001	0.021
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q13	Pearson Correlation	-0.026	-0.088	-0.134	0.800	-0.301	0.933(*)	0.365	1.000(**)	0.779	0.956(*)	-0.371	0.991(**)	1	0.963(**)
	Sig. (2-tailed)	0.967	0.888	0.830	0.104	0.622	0.021	0.545	0.000	0.121	0.011	0.538	0.001		0.008
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Q14	Pearson Correlation	-0.110	0.081	-0.153	0.881(*)	-0.505	0.947(*)	0.388	0.963(**)	0.893(*)	0.910(*)	-0.340	0.933(*)	0.963(**)	1
	Sig. (2-tailed)	0.861	0.897	0.806	0.049	0.385	0.014	0.519	0.008	0.042	0.032	0.576	0.021	0.008	
	N	5	5	5	5	5	5	5	5	5	5	5	5	5	5

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Based on correlation Pearson in Table 4.31, it showed the correlation value for Question 1 until Question 14 which got from SPSS software. There were significant correlation range that 0.00 which means no correlation, 0.01-0.30 weak correlation, 0.30-0.50 low correlation, 0.50-0.70 average correlation, 0.70-0.90 high correlation and 0.90-1.00 is high and strong correlation.

From the correlation value above, it showed that Question 1 had high and strong correlation with Question 7. It means that both of them have high significant value. Question 4 had high and strong correlation with Question 9 and vice versa. Question 6 had high and strong correlation with Question 8, 10, 13 and 14. Question 8 had high significant value with Question 6, 10, 12, 13, and 14. Question 10 had high and strong correlation with Question 6, 8, 12, 13 and 14. Question 12 high and strong correlate with Question 8, 10, 13 and 14. Question 13 had high significant value with Question 6, 8, 10, 12 and 14. Question 14 had high and strong correlation with Question 6, 8, 10, 12 and 13. All of the questions involved can be referred in Appendix A1.

4.9 CONCLUSION

For this chapter, it shows the highest velocity, acceleration and distance that can be achieved when performing double instep run which is either the highest value was in a condition of using knee pad or without using knee pad. Multi linear regression to analyse connection between variables involved in this analysis. Then, it showed also the perception analysis based on questionnaire that had been distributed to subject. The analysis was done by using SPSS software to look for the correlation value as to see the connection between all of the questions in Likert scale question.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

For this chapter, it will go through the whole processes that had been done to achieve the objectives for this study which is regarding biomechanical loading on double instep kick for Malaysian footballer where there is comparison between using knee pad and without using knee pad. There will be also recommendation for further study and will be beneficial in football field.

5.2 CONCLUSION AND RECOMMENDATIONS

From the data that had been collected and had been analyzed, the highest velocity can be achieved when performing two step run and without using knee pad which showed 12.6061 m/s. The highest acceleration occur when the subject performing instep kick with two step run and without using knee pad, 630.31 m/s2. Then, the highest value of distance here is when performing instep kick with two step run and without using knee pad which is 48.4611 m and it shows that the biggest hip angle occurred when performing one step run and with the knee pad 140.5556° while the biggest knee angle occurred when applying two steps run while using knee pad 153.00°. Through linear regression analysis, velocity and acceleration variable usable in making force equation model and distance is neglected since its having low significant value to force model.

Through multi-linear regression analysis method, an equation which relates the force model with all other variables obtained. Prediction equations using the right foot for double instep kick as shown as follows:

i. For one step and with knee pad:

$y = 0.00170 + 696\ x_1 - 0.000001\ x_2 - 0.0133\ x_3$

Where, y equal to force and x equal to velocity, acceleration and distance.

ii. For two steps and with knee pad:

$y = 0.00010 + 696\ x_1 + 0.000001\ x_2 - 0.0014\ x_3$

Where, y equal to force and x equal to velocity, acceleration and distance.

iii. For one step and without knee pad

$y = 0.00018 + 696\ x_1 + 0.000003\ x_2 - 0.0014\ x_3$

Where, y equal to force and x equal to velocity, acceleration and distance.

iv. For two steps and without knee pad

$y = -\ 0.00278 + 696\ x_1 - 0.000004\ x_2 + 0.0148\ x_3$

Where, y equal to force and x equal to velocity, acceleration and distance.

For the correlation analysis, the questions involved were as in Appendix A1 and it referred to the usage of knee pad to football player. Thus, it showed that Question 1 had high and strong correlation with Question 7. It means that both of them have high significant value. Question 4 had high and strong correlation with Question 9 and vice versa. Question 6 had high and strong correlation with Question 8, 10, 13 and 14. Question 8 had high significant value with Question 6, 10, 12, 13, and 14. Question 10 had high and strong correlation with Question 6, 8, 12, 13 and 14. Question 12 high and strong correlate with Question 8, 10, 13 and 14. Question 13 had high significant value with Question 6, 8, 10, 12 and 14. Question 14 had high and strong correlation with Question 6, 8, 10, 12 and 13.

In this study, there are a few suggestions that will be proposed to enhance and improve the distance when kicking the ball is kicked. They can be used for further research later on. Analysis that relates factors when making a kick to the accuracy of the kicked ball for example the quality of field and type of ball can be done. For example, the study of the field structure can be made where the research will be done next is to study the structure of grass and synthetic field. Different surface field can provide a huge impact on the kick. In addition, the other suggestion is to do research on subject performing instep kick while using shin guard or not using shin guard. The study may look through the effects of the speed to the ball and the distance of the ball. The muscle strength can also be analyze and compare if subject use knee pad or not using knee pad while performing instep kick.

5.3 CONCLUSION

With this study, perhaps the application of biomechanical principles to sport can improve the understanding of movement mechanisms, assess and improve performance and provide knowledge to prevent injuries.

REFERENCES

Abt, J.P., Sell, T.C., Chu, Y., Lovalekar, M., Burdett, R.G., Lephart, S.M. 2011. Running Kinematics And Shock Absorption Do Not Change After Brief Exhaustive Running. *Journal of Strength and Conditioning Research*. Vol.**0**, No. 0, 1-7.

Andersen, T.B., Kristensen, L.B., Sorensen H. 2008. Biomechanical Differences between Toe and Instep Kick- Influence of Contact Area on the Coefficient of Restitution. *Football Science.* Vol.**5**, 45-50.

Apriantono, T., Ikegami, Y., Sano, S., Nunome, H. 2004. Effect of Leg Muscle Fatigue on Instep Soccer Kick. ISBS 2004/ Ottawa, Canada, 577-579.

Arnason, A., Sigurdsson, S.B., Gudmundsson, A., Holme, I., Engebretsen, L., Bahr, R. 2004. Physical Fitness, Injuries, and Team Performance in Soccer. *Med Science Sport Exercise*. **36**(2), 278-285.

Asai, T., Carre, M.J., Akatsuka, T., Haake, S.J. 2002. The Curve Kick Of A Football I: Impact With The Foot. *Sports Engineering* (2002). **5,** 183-192.

Baktash, S., Hy, A., Muir, S., Walton, T., Zhang, Y. 2009. The Effects of Different Instep Foot Positions on Ball Velocity in Place Kicking. *International Journal of Science and Engineering.* Vol. **03**, No.02, pp 085-092.

Bangsbo, J., Mohr, M., Krustrup, P. 2006. Physical and Metabolic Demands of Training and Match-Play in the Elite Football Player. *Journal of Sports Sciences*. **24**(7): 665-674.

Barfield. 1998. *Clinics in Sports Medicine*. 17,4.

Barfield, W. 1995. Effects of Selected Kinematic and Kinetic Variables on Instep Kicking with Dominant and Nondominant Limbs. *Journal of Human Movement Studies*. **29**, 251-272.

Barfield, W.R., Kirkendall, D., Yu, B. 2002. Kinematic Instep Kicking Differences Between Elite Female And Male Soccer Players. *Journal of Sports Science and Medicine*. **3**, 72-79.

Bartlett, R. 2004. Is Movement Variability Important For Sports Biomechanists. ISBS 2004/ Ottawa, Canada, 521-524.

Bartlett, R. 2007. *Introduction to Sports Biomechanics: Analysing Human Movement Patterns.* 2nd Edition. ISBN 0-203-46202-5

Bjelica, D., Georgiev, G., Popovic, S. 2011. Comparison of Instep Kicking By Non-Preferred Leg among Various States and Intensities in Young Football Players. *Acta Kinesiologica* 5, **1**: 79-82.

Bloomfield, J., Polman, R., O'Donoghue, P. 2007. Physical Demands of Different Positions in FA Premier League Soccer. *Journal of Sports Science and Medicine*. **6**, 63-70.

Brophy, R.H., Backus, S.I., Pansy, B.S., Lyman, S., Williams, R.J. 2007. Lower extremity muscle activation and alignment during the soccer instep and side-foot kicks. *Journal of Orthopaedic and Sports Physical Therapy.* Number 5, Volume **37**, 260-268.

Bubanj, S., Stankovic, R., Joksimovic, S., Bubanj, R., Joksimovic, S., Kozomara, G., Efthimiadis, P. 2010. *Kinematics of Accurate Inside of Foot Kick: Kinesiologica Slovenica.* **16,** 1-2, 75-83, ISSN 1318-2269.

Bull-Andersen, T., Dorge, H., Thomsen, F. 1999. Collisions in Soccer Kicking. *Sports Engineering.* **2**, 121-125.

Burrows, M., Morris, G. 2001. The Kinematics and Neural Control of High-Speed Kicking Movement in the Locust. *The Journal of Experimental Biology.* **204**, 3471-3481.

Cabri, J., De Proft, E., Dufour, W., Clarys, J. 1988. The Relation between Muscular Strength and Kick Performance. In: *Science and Football*. Eds: Reilly, T.,Lees, A., Davids, K., Murphy, W. London: E &FN Spon.186-193.

Cerulli, G., Lamontagne, M., Caraffa, A., Brue, S., Liti, A., Raggi, A. 2004. Biomechanics of Injury: It's Role in Prevention, Rehabilitation and Orthopaedic Outcomes. ISBS 2004/ Ottawa, Canada, 417.

Cometti, G., Maffiuletti, N.A., Pousson, M., Chatard, J.C., Maffulli, N. 2001. Isokinetic Strength and Anaerobic Power of Elite, Sub Elite and Amateur French Soccer Players. *Int. J. Sports Med*. 2001; **22**: 45-51.

De Proft, E., Clarys, J., Bollens, E., Cabri, J., Dufour, W. 1988. Muscle Activity in the Soccer Kick. In: *Science and Football*. Eds: Reilly, T., Lees, A., Davids, K., Murphy, W.J. London: E &FN Spon.186-193.

Deegan, M. 1952. *Recognizing, Treating, and Preventing Common Soccer Injuries.*

Dorge, H.C., Andersen, T.B., Sorensen, H., Simonsen, E.B. 2002. Biomechanical Differences in Soccer Kicking with the Preferred and Non Preferred Leg. *Journal of Sports Sciences*. **20**:4, 293-299.

Dutta, P., Subramanium, S. 2002. Effect of Six Weeks of Isokinetic Strength Training Combined with Skill Training on Soccer Kicking Performance. *In: Science and Soccer IV*. Eds: Sprinks, W., Reilly, T., and Murphy, A. London: Taylor and Francis. 334-340.

Edward, T. 1983. *The Visual Display of Quantitative Information. Graphic Press.*

Ekblom. 1986. Applied Physiology of Soccer. *Sports Medicine.* **3**, 50-60.

Ekblom, B. 1994. *Football (Soccer).* Blackwell Scientific Publications.

Eriksson, E. 2004. How a Sports-Orthopaedic Surgeon Realized the Importance of Biomechanics, ISBS 2004/ Ottawa, Canada, 67-68.

Finnoff, J.T., Newcomer, K., Laskowski, E.R. 2002. A Valid and Reliable Method for Measuring the Kicking Accuracy of Soccer Players. *Journal of Science and Medicine in Sports.* **5**(4), 348-353.

Flores, M., Smith, D.R. 2004. A Comparison of Cushioning Effect of Three Top Rated Running Shoes and a Shoe Using a New Spring Technology. ISBS 2004/Ottawa, Canada, 469-472.

Gabett, T.J. 2005. Science in Rugby League Football: A Review. *Journal of Sports Science*. **23**(9): 961-976.

Gheidi, N., Sadeghi, H. 2010. Kinematic Comparison of Successful and Unsuccessful Instep Kick in Indoor Soccer. *American Journal of Applied Sciences* **7**(10):1334-1340, ISSN 1546-9239.

Godik, M., Fales, I., Blashak, I. 1993. Changing the Kicking Accuracy of Soccer Players Depending On the Type, Value and Aims of Training and Competitive Loads. *In: Science and Soccer II*. Eds: Reilly, T., Clarys, J., Stibbe, A. London: E &FN Spon. 254-260.

Goktepe, A., Karabork, H., Ak, E., Cicek, S., Korkusuz, F. 2008. *Kinematic Analysis on Penalty Kick in Soccer.*

Goodstein, B. 2010. *Preventing ACL Injuries in Soccer.*

Gordon Robertson, Graham Caldwell, Joseph Hamill, Gary Kamen, Sandy Whittlesey. 2004. *Research Methods in Biomechanics.*

Hatze, H. 1974. The Meaning of Term Biomechanics. *Journal of Biomechanics* **7**: 189-190.

Hay, J. 1993. *The Biomechanics of Sports Techniques.* Englewood Cliffs, NJ: Prentice-Hall.

Hobson, K. 2011. *New Steps to Help Prevent Knee Injuries in Teen Sports.*

Huddleston, D., Huddleston, K. 2003. www. soccerhelp.com.

Hudson, J.L, 1986. Coordination of Segments in the Vertical Jump. *Medicine in Science and Sports and Exercise*. **18**(2), 242-251.

Ismail, A.R., Mansor, M.R.A., Ali, M.F.M., Jaafar, S., Johar, M.S.N.M. 2010. Biomechanics Analysis for Right Leg Instep Kick. *Journal of Applied Sciences* **10**(13): 1286-1292, ISSN 1812-5654.

Isokawa, M., Lees, A. 1988. A Biomechanical Aanalysis of the instep kick motion in soccer. *In: Science and Football*. Eds: Reilly, T., Lees, A., Davids, K., and Murphy, W. London: E &FN Spon.449-455.

Kellis, E., Katis, A. 2007. Biomechanical Characteristics and Determinants of Instep Soccer Kick. *Journal of Sports Science and Medicine*. **6,** 154-165.

Kellis, E., Katis, A., Gissis, I. 2004. Knee Biomechanics of the Support Leg in Soccer Kicks from Three Angles of Approach. *Medicine and Science in Sports and Exercise.* **36,** 1017-1028.

Kermond, J., Konz, S. 1978. Support Leg Loading in Punt Kicking. *Research Quarterly*. **49**, 71-79.

Khorasani, A.M., Osman, N.A.A, Yusof, A. 2009. Biomechanical Responses of Instep Kick between Different Positions in Professional Soccer Players. *Journal of Human Kinetics Section 1 Kinesiology*. Volume **22**: 21-28.

Khorasani, A.M., Osman, N.A.A, Yusof, A. 2010. Kinematic Analysis: Number of Trials Necessary to Achieve Performance Stability during Soccer Instep Kicking. *Journal of Human Kinetics Section 1 Kinesiology.* Volume **23:** 15-20.

Kleindienst, F.I., Morrison, R., Walther, M., Kalin, X. 2004. Position and Alignment of Flex Zones in Running Shoes. ISBS 2004/ Ottawa, Canada, 191-194.

Lees A., Nolan, L. 1998. The Biomechanics of Soccer: A Review. *Journal of Sports Science*, **16,** 211-233.

Lees, A. 1996. Biomechanics Applied to Soccer Skills. *In: Science and Soccer*. Ed: Reilly, T. London: E &FN Spon. 123-133.

Luhtanen, P. 1988. Kinematics and Kinetics of Maximal Instep Kicking In Junior Soccer Players. *In Science and Football*. 441-448.

Manolopoulus, E., Papadopoulus, C., Kellis, E. 2004. Effects of Combined Strength and Kick Coordination Training On Soccer Kick Biomechanics in Amateur Players. *Scandinavian Journal of Medicine and Science in Sports*. **16:** 102-110.

Manolopoulus, E., Papadopoulus, C., Prassas, S., Kellis, E., Ostarello, J. 2004. Effects of a Ten Week Training Program on Physical Conditioning and Instep Kick Kinematics in Soccer. ISBS 2004/ Ottawa, Canada, 345.

Manolopoulos, E., Papadopoulus, C., Kellis, E. 2006. Effects of Combined Strength and Kick Coordination Training On Soccer Kick Biomechanics in Amateur Players.*Scandinavian Journal of Medicine and Science in Sports*. **16**, 102-110.

Masuda, K., Kikuhara, N., Takahashi, H., Yamanaka, K. 2003. The Relationship between Muscle Cross-Sectional Area and Strength in Various Isokinetic Movements among Soccer Players. *Journal of Sports Science*. **21**, 851-858.

Mohr, M., Krustrup, P., Bangsbo, J. 2005. Fatigue in Soccer: A Brief Review. *Journal of Sport Sciences.* June; **23**(6): 593-599.

Mohr, M., Krustup, P., Bangsbo, J. 2003. Match Performance of High Standard Soccer Players with Special Reference to Development of Fatigue. *Journal of Sports Sciences*. **21**, 519-528.

Moller, B.F. 1982. *Orthopadie*, **11**: 148-153.

Narici, M., Sirtori, M., Mognoni, P. 1988. Maximall Ball Velocity and Peak Torques of Hip Flexor and Knee Extensor Muscles. *In: Science and Football*. Eds: Reilly, T., Lees, A., Davids, K., Murphy, W.J. London: E &FN Spon.429-433.

Nigg, B.M. 2004. Impact Forces and Movement Control- Two New Paradigms. ISBS 2004/ Ottawa, Canada, 3-7.

Nunome, H., Asai, T., Ikegami, Y., Sakurai, S. 2002. Three Dimensional Kinetic Analysis of Side-Foot and Instep Soccer Kicks. *Medicine and Science in Sports and Exercise.* **34**, 2028-2036.

Nunome, H., Ikegami, Y. 2005. The Effect of Hip Linear Motion on Lower Leg Angular Velocity during Soccer Instep Kicking. ISBS 2005/ Beijing, China, 770-772.

Nunome, H., Ikegami, Y. 2006. Kinematics of Soccer Instep Kicking: A Comparison of Two Dimensional and Three Dimensional Analyses. XXIV ISBS Symposium 2006, Salzburg-Austria, MOB 2-3: 12:15- 12:30.

Nunome, H., Ikegami, Y., Asai, T., Sato, Y. 2004. *A Kinematic Comparison of the Inside Soccer Kick Between High Performance Player and Junior Players.*

Nunome, H., Lake, M., Georgakis, A., Stergioulas, L. 2007. An Alternative Feature of Impact Phase Kinematics of Instep Kicking In Football. *Journal of Sport Science and Medicine.* Suppl. 10.

Opavsky, P. 1988. An Investigation of Linear and Angular Kinematics of the Leg during Two Types of Soccer Kick. *In: Science and Football*. Eds: Reilly, T., Lees, A., Davids, K., and Murphy, W.J. London: E &FN Spon.456-459.

Ozaki, H., Aoki, K. 2007. Kinematic and Electromyographic Analysis of In front Curve Soccer Kick. *Football Science*. Vol.**5**, 26-36.

Parsons, K.C. 2000. Environmental Ergonomics: A Review of Principles, Methods and Models. *Applied Ergonomics.* **31**(2000), 581-594.

Peitersen, B. 1998. *Fodboldteknik-ungdomstranigens ABC.* (Systime: Herning, Denmark).

Plagenhoef. 1971. *Patterns of Human Motion. Englewood Cliffs*, NJ: Prentice-Hall.

Potthast, W., Heinrich, K., Schneider, J., Brueggemann, G.P. 2010. The Success of a SoccerKick Depends on Run up Deceleration. ISBS – Conference Proceedings Archive, 28 International Conference on Biomechanics in Sports. ISSN 1999-4168

Poulmedis, P., Rondoyannis, G., Mitsou, A., Tsarouchas, E. 1988. The Influence of Isokinetic Muscle Torque Exerted In Various Speeds on Soccer Ball

Velocity. *The Journal of Orthopaedic and Sports Physical Therapy*, Vol. **10**, Number 3, 0196 -6011/88/1003-0093.

Poulmedis, P., Rondoyannis, G., Mitsou, A., Tsarouchas, E. 1988. The Influence of Isokinetic Muscle Torques Exerted In Various Speeds on Soccer Ball Velocity. *Journal of Orthopedics and Sports Physical Therapy.* **10**, 93-96.

Reilly, T. 1996. *Science and Soccer*. E &FN Spon, London.

Reilly, T. 2005. Training Specificity for Soccer. *International Journal of Applied Sports Sciences*, Vol. **17**, No. 2, 17-25.

Reilly, T., Thomas, V. 1976. A Motion Analysis of Work-Rate in Different Positional Roles in Professional Football Match-Play. *Journal of Human Movement Studies.* **2**, 87-89.

Rodano, R., Tavana, R. 1993. Three Dimensional Analysis of the Instep Kick in Professional Soccer Players. *In: Science and Football II*. Eds: Reilly, T., Clarys, J., Stibbe, A. London: E & FN Spon. 357-363.

Roemer, K. 2004. Solving Inverse Problems in Biomechanics Using Leg Extensions as an Example. ISBS 2004/ Ottawa, Canada, 268-271.

Scherger, J.S. The Study of Human Movement by the Application of Biomechanical Musculoskeletal Leverage Physics: Understanding the Effective Lever Arm.

Scurr, J., Hall, B. 2009. The Effects of Approach Angle on Penalty Kicking Accuracy and Kick Kinematics with Recreational Soccer Players. . *Journal of Sports Science and Medicine.* **8,** 230-234.

Shan, G., Zhang, X. 2011. From 2D Leg Kinematics to 3D Full Body Biomechanics-The Past, Present of Future of Scientific Analysis of Maximal Instep Kick in Soccer. *Sports Medicine, Arthroscopy, Rehabilitation, Therapy and Technology.* **3:**23, doi: 10.1186/1758-2555-3-23, ISSN 1758-2555.

Shinkai, H., Nunome, H., Ikegami, Y., Isokawa, M. 2007. Ball-foot Interaction in Impact Phase of Instep Soccer Kick. *Journal of Sports Science and Medicine*, Suppl. 10.

Shirazi-Adl, A., Moglo, K.E. 2004. Knee Joint Ligament Reconstruction: On Pretension and Coupling in Cruciate Ligaments. ISBS 2004/ Ottawa, Canada, 83-86.

Smith, R. 2004. Application of Mechanical Modelling to Sport Biomechanics. ISBS 2004/ Ottawa, Canada, 563-566.

Smith, J., Ball, K., MacMahon, C. 2009. Foot-To-Ball Interaction in Preferred and Non- Preferred Leg Australian Rules Kicking. ISBS - Conference Proceedings Archive, 27 International Conference on Biomechanics in Sports (2009). ISSN 1999-4168

Taina, F., Grehaigne, J., Cornetti, G. 1993. The Influence of Maximal Strength Training Of Lower Limbs of Soccer Players on Their Physical and Kick Performances. *In: Science and Soccer II.* Eds: Reilly, T., Clarys, J., Stibbe, A. London: E & FN Spon. 98-103.

Tanaka, Y., Shiokawa, M., Yamashita, H., Tsuji, T. 2006. Manipulability Analysis of Kicking Motion in Soccer Based on Human Physical Properties. 2006 IEEE Conference on Systems, Man and Cybernetics, October 8-10, 2006/ Taipei, Taiwan, 1-4244-0100-3/06.

Teixera, L. 1999. Kinematics of Kicking As a Function of Different Sources of Constraint on Accuracy. *Perceptual and Motor Skills.* **88,** 785-789.

Van den Bogert, A.J. 2004. Modelling and Computer Simulation in Sports Biomechanics: Application to the Prevention of Knee Ligament Injuries. ISBS 2004/ Ottawa, Canada, 213.

Wesson, J. 2002. *The Science of Soccer*. London: Institute of Physics Publishing.

Woelfel, K.A., Satern, M.N. 2004. The Effect of Tape on the Amount and Rate of Ankle Inversion Before, During, and After 60 Minutes Exercise. ISBS 2004/ Ottawa, Canada, 183-186.

Wrigley, W.M., Chow, J.W., Tillman, M.D., Siders, R.A. 2004. *Effects of Ankle Stabilization on Push-Off Mechanics From a Three Point Stance In Football*. ISBS 2004/ Ottawa, Canada, 75-78.

APPENDICES

APPENDIX A1

QUESTIONNAIRE

This survey forms are part of a study on biomechanics field for football games. The main study of this study is **to compare either using knee pad or without knee pad that give optimum value while performing double instep kick.**

INSTRUCTIONS: Please read the questions carefully before answering them. Where appropriate, tick (/) in the box or complete the answer in space provided.

1. Gender: ☐ Male ☐ Female
2. Age: ____________
3. Height: ____________cm
4. Weight: _____________kg
5. Status: ____________
6. Occupation: _____________
7. Race : _________________

****

8. How long have you played football?
   - ☐ Less than a year
   - ☐ 1-2 years
   - ☐ 3-5 years
   - ☐ 6 years and above
9. In the past days or weeks or months, did you get any injury?
   - ☐ Yes (Please specify wht kind of injury:____________________________)
   - ☐ No
10. What is your position in your team?
    - ☐ Striker
    - ☐ Goalkeeper
    - ☐ Middle player
    - ☐ Defender
    - ☐ . (Please specify:_____________)
11. In general, would you say your health is
    - ☐ Excellent
    - ☐ Very good
    - ☐ Good
    - ☐ Fair
    - ☐ Poor
12. In the past six months, did you undergo any operation?
    - ☐ Yes. (please specify:___________________________)
    - ☐ No
13. What is your preferred leg?
    - ☐ Right
    - ☐ Left
14. Which type of football shoes that you prefer the most?
    - ☐ Nike
    - ☐ Adidas
    - ☐ Lotto
    - ☐ Other. (Please specify:_______________________)
    - ☐ Asics

15. How often do you have your training per week?
    - [ ] 1-2 days
    - [ ] 3-4 days
    - [ ] 5 days and above

16. How many hours in a day for training?
    - [ ] Less than an hour
    - [ ] 1-2 hours
    - [ ] More than 2 hours.

****

Please state your comment regarding on using knee pad or without knee pad while kicking by ticking (/) on given scale.

Scale: (1) Totally disagree (2) Disagree (3) Not sure (4) Agree (5) Totally agree

	(1)	(2)	(3)	(4)	(5)
Knee pad is comfortable to wear					
With and without knee pad in kicking will affect kicking technique					
Frequently use knee pad to play football					
Using knee pad lead to hard to move the leg					
Knee pad give maximum protection to the knee					
Knee pad can improve kicking speed					
Knee pad is one of main equipment in football games for players					
Knee pad can lead to better performance of kicking					
Ball velocity increase by using knee pad					
Ball velocity decrease by using knee pad					
Knee pad give more flexibility to the leg movement					
Accuracy of kicking increase with using knee pad					
Ball distance increase when using knee pad					
Force towards the ball increase when using knee pad					

THANK YOU!