Journal of Applied Sciences 10 (13): 1286-1292, 2010
ISSN 1812-5654
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Biomechanics Analysis for Right Leg Instep Kick

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Abstract: High quality kicking technique is the most important aspect of the soccer player. The good kicking technique will increase quality of the games. The study will focus on the biomechanics analysis of the national soccer players as well as identifying to their kicking action and technique using the instep kicking. The subject making the instep kicking by using the right leg. Data management and analysis were performed using Silicon Pro Coach and the statistical analysis carried out by using Minitab software. Image of instep kicking was captured during the study to obtain a visual of the kicking activity so that it can be analyzed. From that, the data for velocity, acceleration, angle of ankle and distance involved in kicking activity can be identified. Furthermore, the equation that relates with the variables were obtained through the ANOVA and regression model for each variable. Based on the findings, the velocity and distance was identified as significant to the force model. This study has shown that the highest average forces produced in force model analysis which using three step run. The highest average force is 5879.60 N, the highest average velocity is 8.2 m sec^{-1} ec with distance kick as much as 47.85 m and the multi linear model equation is $y = - 18.1+711x_1+0.146 x_2+396x_3$.

Key words: In-step, kick, distance, force, velocity, angle

INTRODUCTION

Nowadays, science and technology development has propelled all researchers develop worldwide variety field which among them is in field of sports. In the field of sports, all researchers have made numerous studies about performance and development of athlete at every sort of game with used biomechanics method which it to increase sports development quality for every country. The most widely studied soccer kick is the instep kick (Lees and Nolan, 1998; Nunome *et al*., 2006; Apriantono *et al*., 2006). An understanding of the biomechanics of kicking can assist the coaching process. Coaching experience, combined with knowledge of a mechanical model of the desired performance, is regarded as necessary for a coach to correct performance (Elliott, 2001; Lees, 2002).

Instep kicking has been studied from the youngest age groups to seasoned professionals (Asami and Nolte, 1983; Luhtanen, 1988). The instep kick generally uses the laces of the shoe to strike the ball. A key factor in the success of any kick in soccer is the placement of the supporting foot (the non-kicking foot plant) If the support foot is improperly positioned relative to the ball, the resultant kick will likely be errant. When kicking with the right foot, the approach should be from behind and to the left of the ball; the approach is made from behind and to the right of the ball when kicking with the left foot.

Success of an instep soccer kick depends on various factors including the distance of the kick from the goal, the type of kick used, the air resistance and the technique of the main kick which is best described using biomechanical analysis. Previous reviews have examined biomechanics of soccer movements in-detail (Lees, 1996; Lees and Nolan, 1998). The basic (two-dimensional) kinematics of the lower limb segments during instep soccer kicks have been previously reviewed (Lees, 1996; Lees and Nolan, 1998). These include examination of angular position-time and angular velocity curves during the kick as well as the linear kinematics of the joints involved. The higher the speed of the foot before impact, the shorter the foot-ball contact and the highest the ball speed. For this reason, the ball-to-foot speed ratio has been considered as an index of a successful kick (Asami and Nolte, 1983; Kellis *et al*., 2004; Lees and Nolan, 1998; Nunome *et al*., 2006; Plagenhoef, 1971). For instep kicks, ball-to-foot speed ratios reported in the literature range from 1.06 to 1.65 (Asami and Nolte, 1983; Isokawa and Lees, 1988; Kellis *et al*., 2004; Kellis *et al*., 2006; Nunome *et al*., 2006) depending on the foot area used to examine foot speed.

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A soccer kick may be performed either from a stationary position or at a certain distance from the ball. The approach consists of several steps and can be performed at an angle relative to the ball. The length, speed and angle of approach are the most important aspects of this preparatory movement which has a significant effect on soccer kick success (Isokawa and Lees, 1988; Kellis *et al*., 2004). Kicking from an angled approach up to 45° may increase ball speed, although this increase may not be statistically significant (Isokawa and Lees, 1988). Kick in habit its used when player taking free kick, penalty kick and also shooting. So in this analysis, movement of kicking through impact phase in ball when player making kick will be study. Apart from that, injury in fetlock often happened excess loading result given when kick carried out. Effect which found of this problem cause failed player giving performance and good game and often make mistakes when play.

Further, kicking with running approach demonstrates higher ball speed values compared with static approach kicks. To our knowledge, the difference between one-step and multi-step approach on ball speed values is not clear. However, practice shows that soccer players prefer a multi-step approach, most often 2 or 3 steps prior to the main kicking action. Ball speed values during the maximum instep kick range from 18 to 35 msec^{-1} depending on various factors, such as skill level, age, approach angle and limb dominance. Accurate kicks are generally slower than powerful kicks. The full instep kick has been biomechanically studied in detail defining its typical components including the foot/ball contact phase. Successful kicks need to be fast and accurate, especially when kicking on goal. The distance, velocity and angle imposed kicking are the important parameters involving the kicking activities where it can contribute high impact to effectiveness of kicking (Kellis *et al*., 2004). Therefore, this study will focus more on the biomechanics analysis towards the soccer players besides to identifying to their kicking action and technique using the instep kicking. Among the different instep kicking techniques the full instep kick is the fastest, followed by the inner and outer instep kicks (Neilson and Jones, 2005). In this research, the quantitative biomechanics analysis was introduced. The study was executed by quantitative measurement as well as quantitative biomechanics analysis. On the other hand, if the aspect is assessed by observation and survey, the results of the analysis are known as qualitative biomechanical analysis (Luhtanen, 1988).

MATERIALS AND METHODS

Subject selection: Most important thing is subject has to be in good health during experiment because the kick that will be done is from self force. The subject was selected from professional soccer player with average heights of Asian. Height, weight, age and body size of the subject was considered as data for analysis Observation started when subject stops kicking the ball where posture of the leg from waist to knee and then to ankle was observed.

Study setup: The study was conducted on July 2008 at the field of National Sports Institute (ISN). One subject has been chosen to do this study. The deflection tape was attached on the lower limb of the subject part that is on the waist, knee and also ankle. The subject movement will be recorded via video recording by video camera that will focus in section lower limb of the subject. Data recording were done with video/picture using two Sony video camera that located at the side and the front view of the subject when making the kicking. This camera can analyse as fast as 0.02 sec frame^{-1}. Preparation for data recording is on Fig. 1. Figure 1 show the study setup for subject making an instep kicking. Two camera will be using for this study that have been place at the front and side view. The camera will focus on the lower limb of the subject when the subject making a kicking to get a better visualized.

Figure 2 presents the methodology process for this study. It started with selection of the subject. The subject

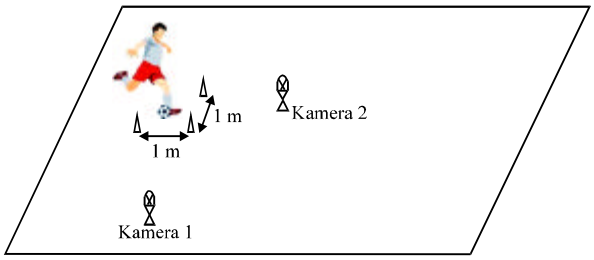

Fig. 1: Study design

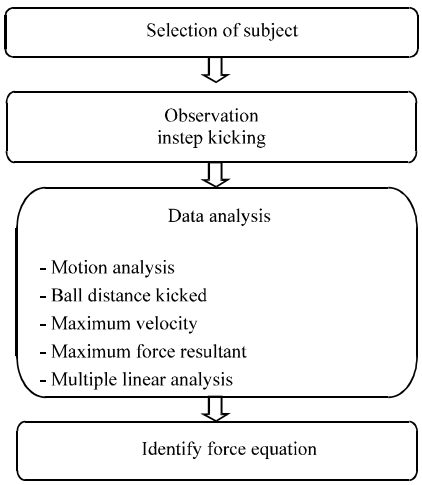

Fig. 2: Methodology process

must be in good condition and release from any injury. The observation will started when the subject making a kicking and it be focused on the lower limb. From that, the data of this study will be analyse about the motion, ball distance, maximum force and multiple linear. Lastly, the force equation will be identify.

Data analysis: In this study, the subject doing instep kick with one step, two step and three step run with two times trial. The subject making instep kicking by using the right leg. Instep kicking activities were recorded by high speed camera video and later the image will be edited through still images according to the frame of every 0.02 per sec^{-1}. Instep kicking were analysed by using the Silicon Pro Coach software (Morrison, 1997). From this analysis, the velocity, acceleration, distance and kicking angle was identified as significant or not significant to the force model. The statistical analysis was conducted by using Minitab software (Farber, 1995).

RESULTS AND DISCUSSION

Motion analysis: Figure 3 presents the edited images from front view according to frame and Fig. 4 presents the

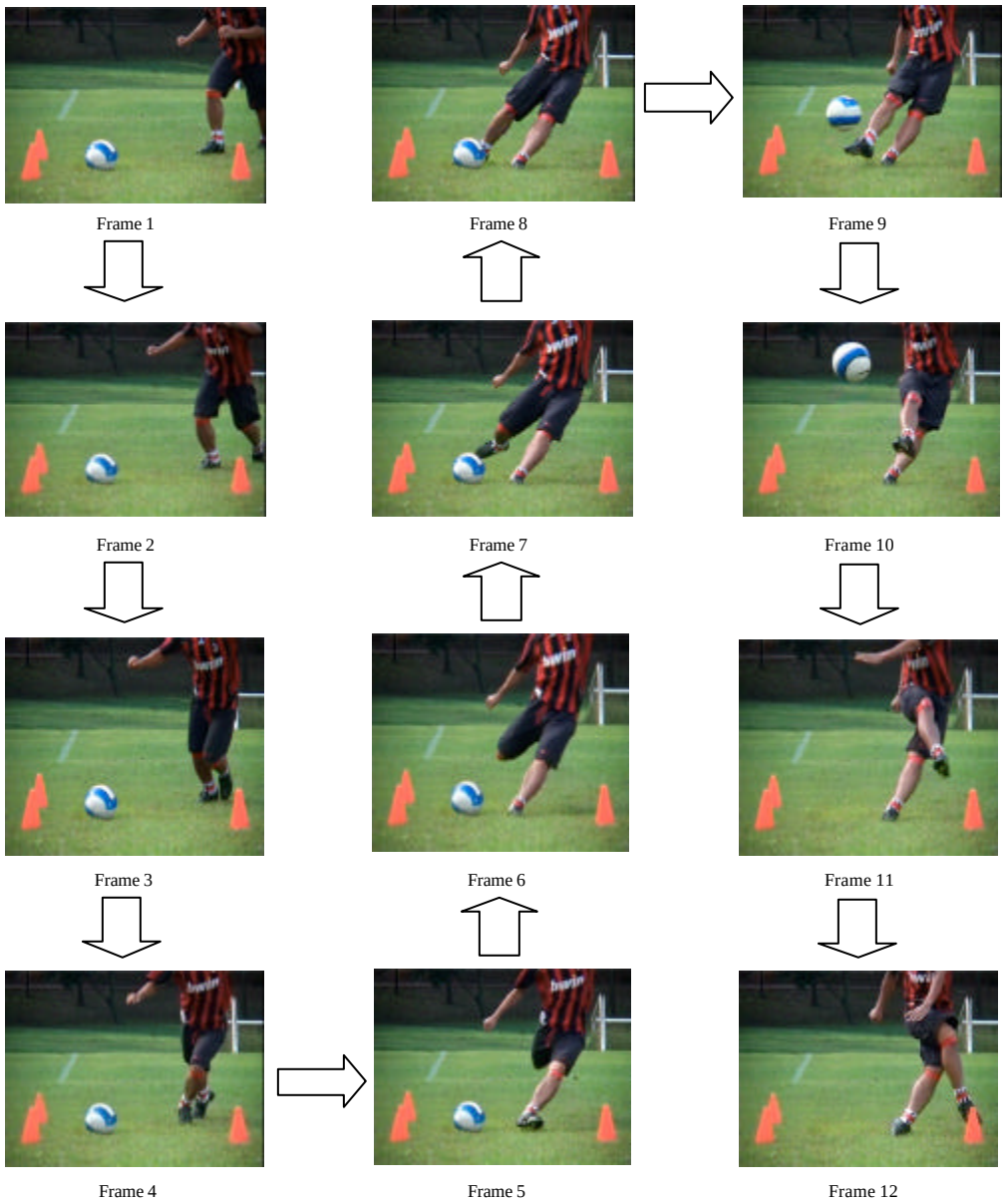

Fig. 3: Front view kicking pictures according to frame

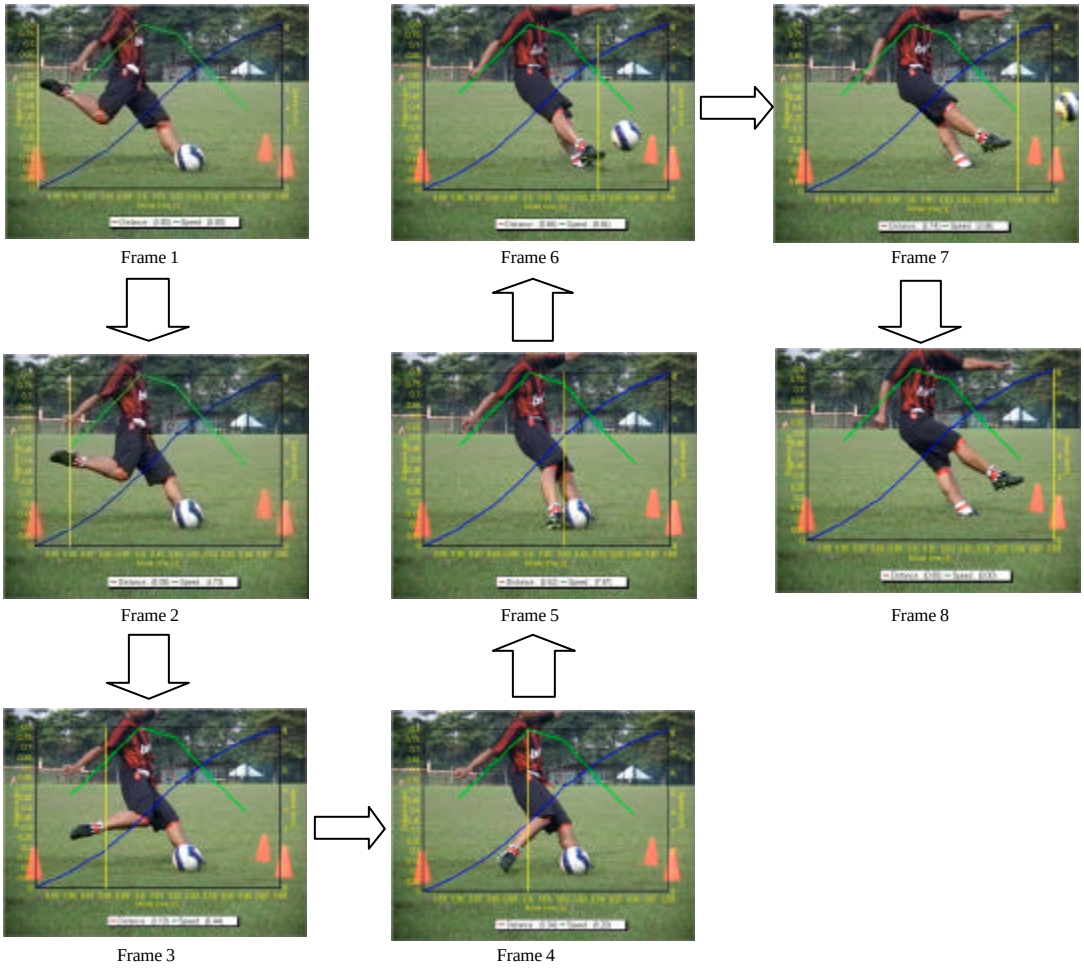

Fig. 4: Side view kicking pictures according to frame

edited images from side view according to frame. Kicking in each frame will be analyzed according to angle, acceleration, kicking velocity and frame distance at ankle.

Figure 5 shows the angle where the subject started making kick and the angle when kicking in ball is carried out. The reading angle also gained by using reading at every frame. This angle was measured from hip point, knee point and ankle point of the kicking leg. The length, speed and angle of approach are the most important aspects of this preparatory movement which has a significant effect on soccer kick success (Isokawa and Lees, 1988; Kellis *et al*., 2004).

Figure 6 shows, the subject which uses right leg started making a kicking. The analysis which made are when subject doing a two step run which it will be analyzed by using software Silicon Pro Coach. In this figure, it shows the velocity relationship fight every time frame adopted and also the distance when making kicking.

Figure 7 shows the maximum velocity produced in frame 4, which before the foot impact and hit into the ball. The speed at the ankle when frame 4 is 8.20 m sec^{-1}.

Figure 8 shows the beginning impact in ankle and ball part which the velocity in ankle will decline consequence of the impact which occurred. Velocity at the moment is 7.67 m sec^{-1} which velocity value lesser as much as 0.53 m sec^{-1}. After the impact happened, the velocity will decreased until subject finish doing kicking. Kicking distance will be measured after kick carried out and drop ball falling on field surface will be recorded his distance.

Figure 9 shows the resultant angle when ankle and ball touching (foot and ball impact happened). This angle is analyzed from waist, knee and ankle part which angle resultant is 141°. From this study, it show that the highest force produced in frame 4, where it occur when the ankle touch with ball. Here, the force considered is at ankle part because that part more hit the ball when making kick

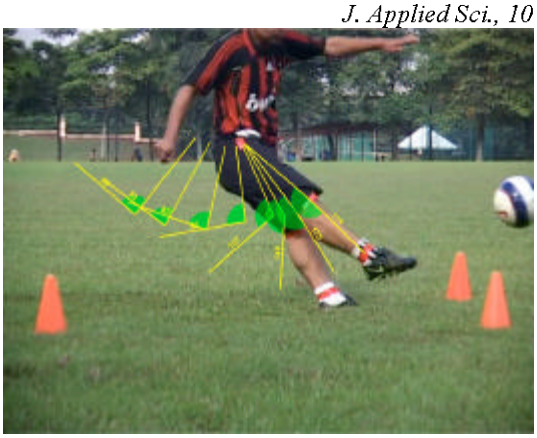

Fig. 5: The angle of subject making kicking

Fig. 6: Graf velocity against time

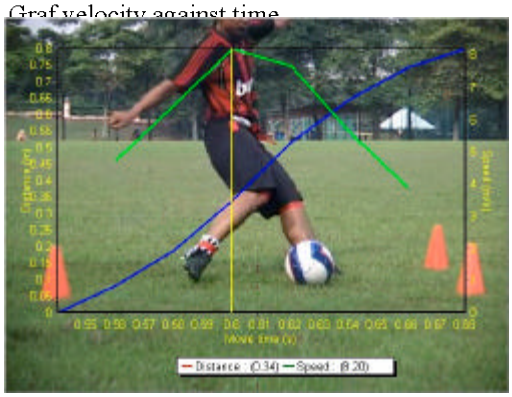

Fig. 7: Graf velocity fight maximum time achieved

compared to knee part and waist. The results of this study indicate that the angle of kicking is 39°. Good kicking angle has been stated previously in earlier research the angular kick is 45°. The foot velocity reduction before the foot touching the ball would give the high impact to the force inflicted by foot on ball. Anderson and Sidaway

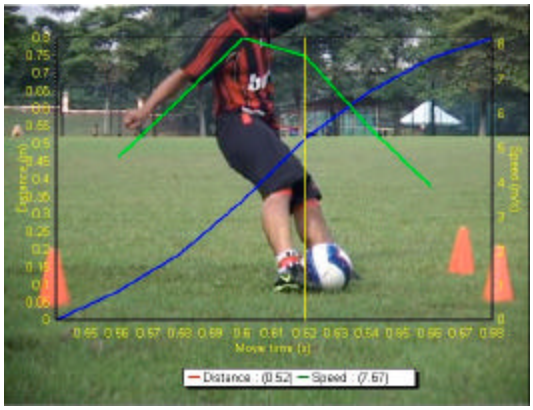

Fig. 8: Graf velocity against time at frame 5

Fig. 9: The angle of right leg subject

Table 1: Ball distance kicked for all run type

	Data of right leg	
Run type	Trial	Distance (m)
First step	1	41.9
	2	39.9
Second step	1	44.9
	2	46.7
Third step	1	47.2
	2	48.5

(1994) analysed the co-ordination of the low instep kick using timing variables and angle plots. In this analysis, it found time and distance is course of doing dependent variable kicking.

Table 1 presents the ball distance kicked achieved from the subject in two trials. It shows that the three steps run have a better distance then other type run when making kicking. So, making kicking with a lot of run can give a better distance. Further, kicking with running approach demonstrates higher ball speed values compared with static approach kicks (Opavsky, 1988).

Table 2 shows the maximum velocity resultant is in three step run of the left leg subject namely the maximum

Table 2: The maximum velocity for all run type

Run type	Max. velocity (m sec^{-1})
First step	7.74
Second step	7.88
Third step	8.20

Table 3: The maximum force resultant for each run type

Run type	Max. velocity (m sec^{-1})	Max. force (N)
First step	7.74	5549.850
Second step	7.88	5650.236
Third step	8.20	5879.600

velocity resultant was 11.71 m sec^{-1}. For the right leg subject the maximum velocity resultant is 8.20 m sec^{-1}. The foot velocity before ball kicked is directly proportional with force imposed against ball.

In this analysis, the force resultant of lower limb can be analyse through Minitab and Silicon Coach Pro software. With run expansion, the force resultant before ball kicked will be increase. From Table 3, it show that the highest average force of right leg produced in force model analysis which using the three step run. In three step run, the highest average force produce is 5879.60 N and the highest average velocity is 8.2 m sec^{-1}.

Multiple linear modelling:

$$y = -18.1+711x_1+0.146x_2+396x_2$$

From the multiple linear regression for all variables it recorded that $R^2 = 1.000$ and the output R^2 x 100% = 100% where R^2 is the coefficient of determination. This can be interpreted as indicating that the model containing distance, acceleration and angle for approximately 100% of the observed variability in force. The model equation that been used is:

$$\hat{Y} = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3$$

Figure 10 show the multiple linear graf for all variable in three step run. The Minitab output show that the least square point estimates of the model parameter are:

$$\beta_0 = -18.1,\ \beta_1 = 711,\ \beta_2 = 0.146 \text{ and } \beta_3 = 396$$

where, β_1 is velocity, β_2 is acceleration and β_3 is distance. The multi linear model equation for three step run is:

$$\hat{y} = -18.1+711x_1+0.146\ x_2+396x_3$$

This study also show the multi linear model equation for all type run using first step, second step and three step run:

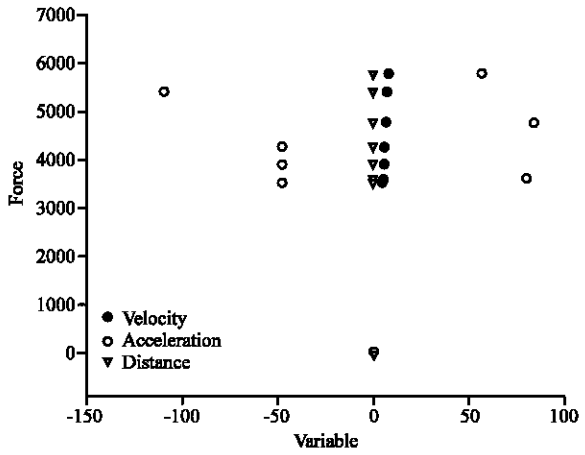

Fig. 10: The multiple modeling for all variable in three step run

- First step

$$\hat{y} = -0.0047+717x_1+0.000062x_2+0.000062x_3$$

- Second step

$$\hat{y} = 0.000202+717x_1+0.000002\ x_2 - 0.00035\ x_3$$

- Third step

$$\hat{y} = -18.1+711x_1+0.146\ x_2+396x_3$$

where, y is level of ability, x_1 is velocity, x_2 is acceleration and also x_3 is distance.

CONCLUSION

This study has shown that the highest average forces produced in force model analysis which using three step run. The highest average force of instep kicking is 5879.60 N, the highest average velocity is 8.2 m sec^{-1} with distance kick as much as 47.85 m and the multi linear model equation is $\hat{y} = -18.1+711x_1+0.146\ x_2+396x_3$. It also show that the instep kicking using a lot of step run will give the highest average force, average velocity and distance. This study was done to obtain the equation that relates with the variables and to get the force model equation when kicking have been made. It is hoped that this study would be beneficial to the Malaysian soccer to get the better techniques in kicking and avoid from injury.

ACKNOWLEDGMENT

This study was financially supported by Ministry of Higher Education of Malaysia under Sport Research Grant

with a close collaboration by National Sports Institute of Malaysia (06-01-02-SF0543).

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