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Biomechanics Analysis on Ankle during Instep Kicking

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Abstract

Soccer sport in Malaysia has yet far to reach the targeted achievement. It was noted that it had only managed to be in the ranking of 160 in the FIFA and also in the 29th place in the football confederation Asia (AFC) giving indication that the national soccer team is expected to strive harder for better achievement. After being examined, the national soccer team is proven to be weak in the kicking techniques. This paper will focus on the biomechanics analysis of the national soccer players as well as identifying their kicking action and technique using the instep kicking. Two subjects had been chosen to perform instep kick whom both of them are the experts in the Malaysian football league, with the first subject having the capability to use his right leg and the other subject being comfortable of using his left leg. Data management and analysis adapting Silicon Pro Coach software whereas the statistical analysis was carried out using Minitab software. Image of instep kicking was captured during the study and is useful to get the data of the style of kicking so that it can be analyzed. From here, the data for velocity, acceleration, angle of ankle and distance involved in kicking activity is possible to be identified. Based on the findings, the velocity and distance was identified as significant to the force model. This study has shown that the highest average distance and the modelling equation produced in the force model analysis undergone three-step run.

Keywords: Biomechanics, Distance, Force, Velocity, Angle, In- Step.

1. Introduction

Soccer is the most popular sport on Earth, and has developed into an art form of sorts. This sport is then known as the 'Beautiful Game' as variety of skills are being adopted. The most fundamental and frequently used skills in this spot is the instep kicking. Recent findings on biomechanics of soccer kick performance had identified the weaknesses of this particular research which seek further

investigation in the future. The biomechanics of soccer kicking is particularly essential to guide and monitor the training process.

Biomechanics is the study of the structure and function of biological systems by means of the methods of mechanics (Hatze, H., 1974). Biomechanics includes the study of all living things, plant and animal; for animal bio mechanics investigate only on animals as the subjects of the study; human biomechanics which touches only on human-being and exercise and sport biomechanics includes only humans involved in exercise and sport (Peter Mc Ginnis, 1999). 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 in the study is assessed by observation and survey, the results of the analysis are known as qualitative biomechanical analysis (Luhtanen, 1988).

The most widely studied skill in football is kicking (Lees and Nolan, 1998), with the majority of studies reporting on the two-dimensional (2D) and three-dimensional (3D) kinematics of the low or maximum velocity instep kick (Barfield et al., 2002; Isokawa and Lees, 1988; Lees and Nolan, 2002; Levanon and Dapena, 1998). Kicking is the specific technique in the soccer sport and received considerable attention in biomechanical research (Barfield, 1998). The different kicking techniques in soccer is the most technical bit of the characteristic skill of the game. This has been proven true as the full instep kick has been biomechanically studied in detail defining its typical components including the football contact phase (Barfield, 1998).

Instep kicking has been studied from the youngest age groups to the group of 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 a football player kicks with the right foot, the approach should be from behind and to the left-side the ball. In contrast the approach should be made from behind and to the right-side of the ball whenever the ball is kicked using the left foot.

The key success of an instep soccer kick relies 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 giving the highest rate of the velocity of the ball.

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 angle of up to 45^{o} might result in the increase of the ball speed, although this increase may not be statistically significant (Isokawa and Lees, 1988).

Furthermore, 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 approaches on ball speed values does not have a clear cut. 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 ranges from 18 to 35 msec-1 depending on various factors, such as the level of the skill levels, 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 football contact phase. Successful kicks need to be fast and accurate, especially when it kicked for a goal. The distance, velocity and angle of the kicking are the important parameters involved in the kicking activities as it contributes to the high impact to effectiveness of kicking (Kellis et al., 2004). Therefore, this study will focus more on the biomechanics analysis towards the national soccer players besides to identify to their kicking action and technique using the instep kicking.

2. Research Methodology

2.1 Subject Selection

Two subjects had been chosen to perform instep kick both are the professionals from the Malaysian football league. The subjects that had been chosen is using right leg and other subject using left leg. The anthropometry data on lower limb of the subjects were taken. Height, weight, age and body size of the subjects also been considered as data for the analysis purpose. The most important thing is the subject was in good health during the experiment.

2.2 Study setup

The study was conducted on July 2008 at the field of National Sports Institute (ISN). The deflection tape was attached on the lower limb of the subjects were placed that on the waist, knee and also ankle. The venue for performing experiment had also been fixed using cones with the distance of 1 meter each. The position of the ball is positioned at the middle of the cone as shown in figure 3.1. The subject movement had been recorded using video camera that focused in the section at the part of the lower limb of the subject. Data recording has been done with video/picture using two Sony video cameras. These cameras could analyse for any movement as fast as 0.02 seconds per frame. Preparation for data recording is shown in Figure 1. Figure 1 shows the study setup for subject making an instep kicking. Two cameras were used for this study had been placed at the front and side view. The camera focused on the lower limb of the subject when the subject made a kick to get a better visual.

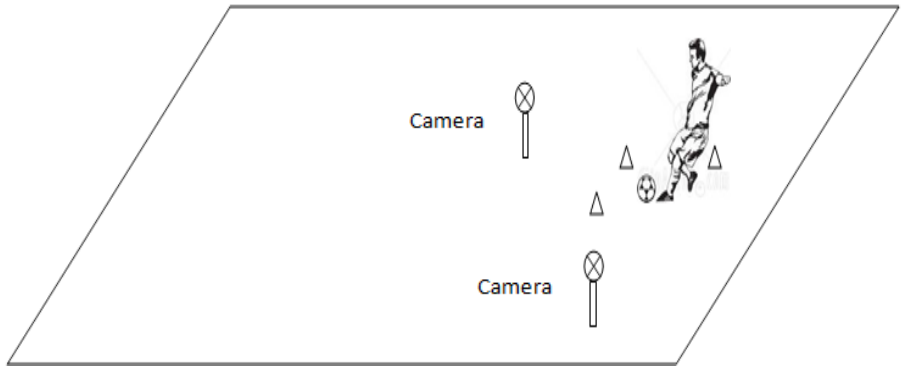

Figure 1: Study Design.

2.3 The activity

The subject were required to kick without running, adapting distinctive steps either one-step run, two-step run and three-step run. The subjects were required to do the same kicking method for 3 times for each kicking type. The Questionnaire were filled by subjects to know about their personal background. As this has been completed, subjects did light exercise or warming up to avoid from the occurrence of injury. The marker tape will be attached in subject lower body part that is on their waist, knee and also ankle. Observation started when subject stopped kicking the ball where the posture of their leg from the waist down to their knee and then to ankle was observed. From here, the data for velocity, acceleration, angle of ankle and distance involved in kicking activity can be identified as significant or not significant to the force model.

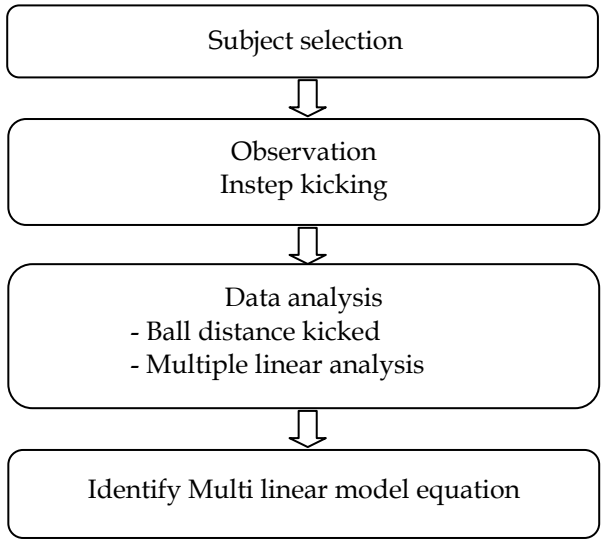

Figure 2 presents the steps of research methodology of this study. It started with selection of the subject. Making sure that the subject must be in good condition and were free from any injury. The observation started when the subject kicked and was focused on the lower limb. From here, the data of this study will be analysed about the ball distance and multiple linear. As the final step, the multi linear model equation of this two subjects will be identified.

3. Result & Discussion

3.1 Data analysis

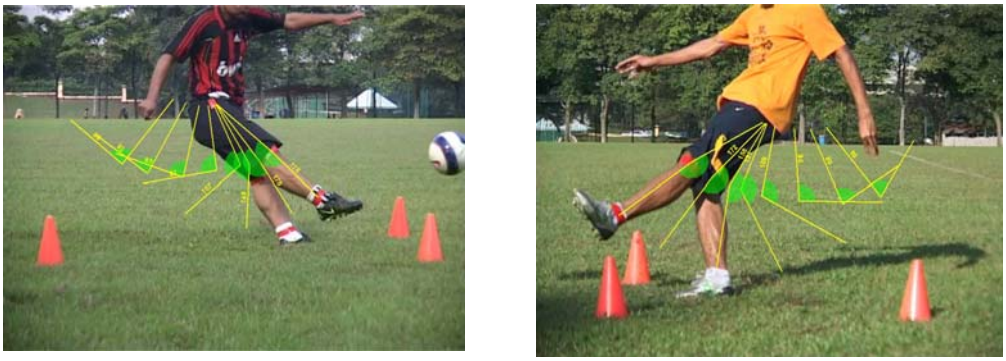

Figure 3: The Angle of Right and Left Leg Subjects Kicking.

Figure 3 shows the angle where the subjects started to kick and the angle when kicking in ball is carried out. The reading angle also gained by readings at every frame. This angle was measured from hip point, knee point and ankle point of the kicking leg.

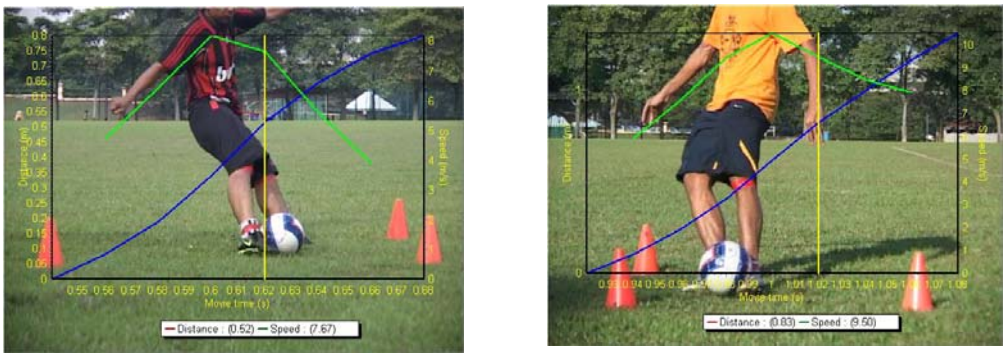

Figure 4: Maximum Velocity Graphs against Time at Frame 5 for Right and Left Leg of the Subjects.

Figure 4 shows the subjects which use right and left leg started to kick. In this figure, it shows the initial impact at the ankle and ball part which the velocity at ankle would decrease as the consequence of the impact occurred. The velocity at the moment for right-leg subject is 7.67m/s which the readings of the velocity noted to be lesser until 0.53 m/s while for left-leg subject is 9.50m/s which the readings of the velocity noted to be until 1.02m/s. The maximum speed at the ankle before the foot hit the ball for right and left leg of the subjects is 8.20 m/s and 10.52 m/s respectively. After the impact had taken place, the velocity will observed to be decreasing until subject ended his kicking action. 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 Sideway (1994) analysed the co-ordination of the low instep kick using time variables and angle plots. Kicking distance will be measured after the ball has been kicked and dropped on the field for any recorded distance. From this study, the ankle contact with ball is put in frame 4, so the subject which uses left leg can do a good kicking with high readings of velocity and the distance. In this analysis, we found out that the time and distance are the biggest factor to contribute to the phenomena of variable kicking.

Table 1: Distance for the Kicked Ball

	Distance (m)	
Run type	**Right leg**	**Left leg**
One step	40.9	43.1
Two step	45.8	47.8
Three step	47.85	50.8

Table 1 shows the distance of the ball kicked obtained from the right and left leg subjects in two trials. From this study, the foot velocity reduction before the foot touching the ball would give the high impact to the force inflicted by foot on ball. The distance of the ball kicked from each left and right foot, vividly prove that kicking distance of right leg would be closer as opposed to the distance produced by the left leg.

From the analysis, the distance of left-leg kicking is noted to be higher, but this result was lower relatively for the right-leg. Lees and Nolan in year (1998), supported this analysis where they claimed that the reduction in ball velocity for right-leg kick is parallel with the angular velocity relatively known to be a powerful kick. It also shows that the three-steps run have a better distance then other type-run when an individual kicking. As a result, kicking with a lot of run can give a better distance result. Furthermore, kicking with running approach demonstrates higher ball speed values as compared to static approach kicks (Opavsky, 1988).

Multiple Linear Modelling

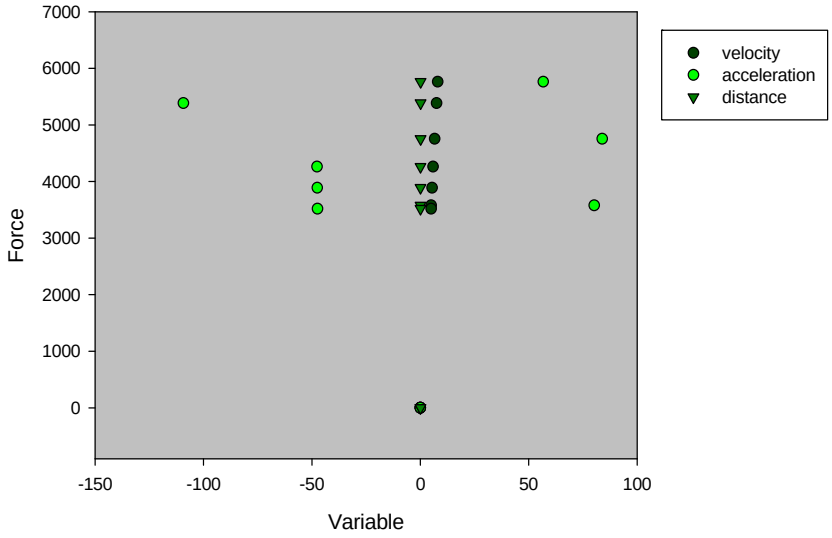

Figure 5: The Multiple Modeling for All Variables in Three Step Run of Subject's Right Leg.

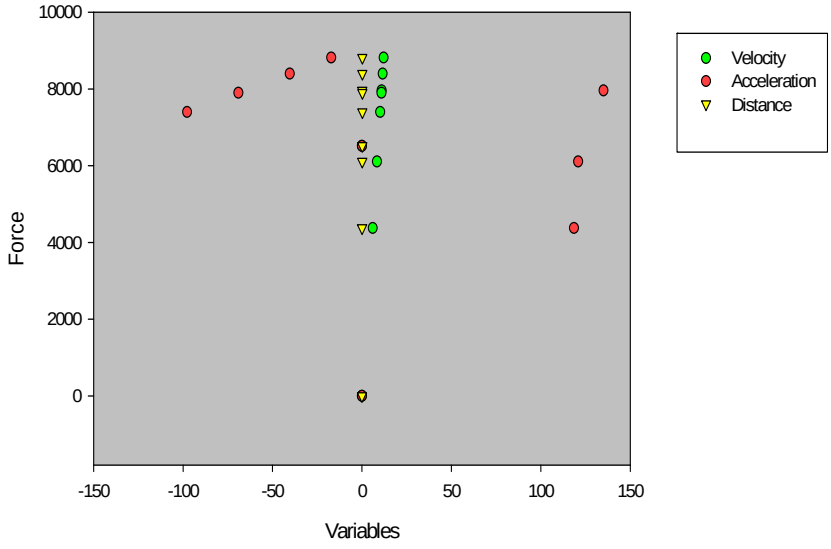

Figure 6: The Multiple Modeling for All Variables in Three Step Run of Subject's Left Leg.

Figure 5 and 6 shows the multiple linear graphs for all variables in three-step run of subject's right and left leg. From the multiple linear regression for all variables it recorded that $R^2 = 1.000$ and the output $R^2 \times 100\% = 100\%$ 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 $\hat{Y} = ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3$. The Minitab output show that the least square point estimates of the model parameter are x_1 , x_2 and x_3 where x_1 is velocity, x_2 is acceleration and x_3 is distance. This study also shows the multi linear model equation for all type run using first step, second step and three step run for subject's right and left leg shows in table 2.

Table 2: Multi Linear Model Equation for Subject's Right and Left Leg

Run type	Multilinear model equation	
	Right leg	**Left leg**
One-step	ŷ = - 0.0047 + 717x1 + 0.000062x2 + 0.000062x3	ŷ = - 2.4 + 721x1 + 0.293 x2 + 0x3
Two-step	ŷ = 0.000202 + 717x1 + 0.000002 x2 - 0.00035 x3	ŷ = - 55 + 738 x1 - 1.09 x2 + 461x3
Three-step	ŷ = - 18.1+ 711x1 + 0.146 x2 + 396x3	ŷ = - 0.073 + 724x1 + 0.00114 x2 + 0.40 x3

4. Conclusion

This study has shown that the highest readings in the distance of the kick and multi linear model equation produced in this analysis by utilizing three-step run. The highest average distance that produced in three-step run is as much as 47.85m for the subject using right leg and 50.8m for the subject using left leg. The multi linear model equation for right leg subject's is $\hat{y} = - 18.1+ 711x_1 + 0.146\ x_2 + 396x_3$ and for the left leg subject's is $\hat{y} = - 0.073 + 724x_1 + 0.00114\ x_2 + 0.40\ x_3$. This study shows that the instep kicking using a lot of step run will give the highest average distance and the equation that relates with the variables to get the force model equation when kicking action is taking place. It is hoped that this study would be beneficial to the Malaysian soccer players to get the better techniques in kicking and avoiding themselves from getting themselves into any type of injury.

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