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Right Leg Biomechanical Analysis during Instep Kicking

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ABSTRACT
This is a biomechanical analysis and optimization of the kicking performance of football players. The main objective in this analysis is to study the 3D biomechanics aspect of instep kicking for the right dominant leg of footballers. The analysis used the 3 subjects of football players which consist of amateur, university, and professional levels. The 3D analysis used was Qualysis Track Manager system, while the optimization process was carried out by applying the Taguchi Method. In this study, the subject has committed a total of 18 times the instep kick with their dominant leg. For all kicks, subjects were asked to perform 3 different types of runoff which were one step, two steps, as well as three steps. Experiments were set at 3 selected variables (control factors) of ankle's velocity (A), time of contact between the legs with the ball (B), and the mass of the dominant leg segment (C). Optimal forces for the subjects who had the right foot dominant with one step running is 1177 N (the optimal A: 13.8 m / s, B: 9.5 ms, C: 13.73 kg). While the two steps and three steps were each given a value of 1544 N (the optimal A: 12.4 m / s, B: 9.0 ms, C: 10.26 kg) and 1662 N (the optimal A: 12.4 m / s, B: 9.0 ms, C: 10.26 kg). Based on the findings, the ankle velocity was identified as significant to the force model. From the Taguchi analysis that was carried out, it was found that the maximum optimized force undergone in three-step run as much as 1662 N. Kicking force increased significantly with each addition of step.
Keywords: Football biomechanics; Instep kicking; Analysis of 3D biomechanics.

I. INTRODUCTION

Based on the objectives of this study, it is an interest for the football industry in the country to strengthen the knowledge and skills of the sport. Analysis for the right dominant foot of footballers is thought to be essential since most of the footballers nowadays have their right leg as their dominant leg. Taguchi method of parameter design provides the design engineer with a method that systematically and consistently to determine the parameters of the optimum design in terms of performance and cost (Phadke 1989). The objective is to select the best combination of parameters that control the product and the process is stable against the noise factors (Unal and Edwin B. Dean 1999).

In the comparative aspects of foot optional factors, a study has shown that the velocity is higher football when players make shots with the preferred or dominant foot (Barfield 1995; Nunome et al. 2006a). This is due to the higher moments produced by the dominant leg compared with the non-dominant leg (narici et al. 1988) and the form of inter-segment better with the transition velocity from the foot to kick the ball during use of the dominant leg (Dorge et al 2001). The study conducted by Nunome et al. (2006a) also showed that the differences in the biomechanical shots depend on the skill level of players. It also states that the higher level skills will lead to factor shots better coordination of both legs.

Experiments were set at 3 selected variables of ankle's velocity (A), time of contact between the legs with the ball (B), and the mass of the dominant leg segment (C). Three variables were selected as the control factors in the Taguchi analysis which were the velocity of the ankle at the time of leg contact with the ball (impact) and the 3 values were referred to the researches that were conducted by previous researchers. Barfield (2002) stated that the ankle's velocity to be at 13.8 m/s, Lees and Nolan (1998), which gives this value of 12.4 m/s and Asai (2002) who had stated this value at 17.0 m/s. For the factor of contact time between the foot and the ball, Asai (2002) also stated that contact time between the legs with the ball was at 9.12 ms. Studies conducted by Shinkai et al. (2007) have expressed this value of 9.5 ms, while the next 2 years, Shinkai et al. (2009) again concluded this value of 9 ms.

For the factor of the mass of leg segments, it has been obtained by using an equation within the book of Biomechanics Research written by D. Gorldon E. Robertson et al. (2004) and by using the anthropometric data of subjects. After doing the calculations, the values for the mass segment were 13.73 kg, 12:42 kg, and 10.26 kg. The equations for total mass of leg segments are as follows:

$m_{foot} = 0.0083\, m_{total} + 254.5\, (l_{feet}\, h_{malleolus}\, \omega_{malleolus}) - 0.065$ (1)

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

$m_{thigh} = 0.1032\, m_{total} + 12.76\, (l_{thigh}\, c^{2\ thigh}) - 1.023$ (3)

$m_{Total} = (1) + (2) + (3)$

II. RESEARCH METHODOLOGY

Subject Selection

This analysis requires a total of three subjects who were selected from the amateur, university, and also professional football players. The subjects have been chosen among the defender, midfielder, and also the striker. First screening process was held to select a total of three subjects with right dominant leg and the rest with a left dominant leg. In this screening process, the subjects also underwent a screening test for injuries that were carried out according to the standard physiotherapy testing. Before doing the kicking, the subject had been prepared in advance and was told about the experiments and experimental risks. Written consent was obtained from them. A total of 16 markers were attached to each subject in certain parts of their bodies at the lower limb. Before carrying out experiments, subjects were also briefed about the experimental procedure, and they have been allowed to perform training exercises with the preliminaries kicking to familiarize themselves with the procedures and testing environment. Experiment was performed in the biomechanics laboratory of UNIMAP. This was because of the A.R. Ismail, M.F.M. Ali, B.M. Deros and M.B.M. Azmin technical limitations and also the regulations which prohibiting us from making it outdoor (football field).

Experimental Setup

Experiment was performed in the biomechanics laboratory of UNIMAP. The equipments used were 5 units of high-speed video camera (Oqus) which have a frequency of 200Hz. System used in this study was the system of Qualysis Track Manager (version 2.0.331 Beta RT) which belongs to UNIMAP. This system was also equipped with a force plate that served as a detector of force during the experiments. Other equipment used was a computer table, 2 calibration bars, 16 reflective markers, an anthropometric ruler, mass scale, a piece of carpet, a pair of shoe, 2 balls in size according to the FIFA standards , a net, pressure meters, and also an air pumps. As a target, a net was dispersed at a bar at the top of the laboratory, which functioned to absorb the impact of experimental kicking. In addition, the net was also used to avoid any risk of damage to the equipments in the event of any errors during the experiment. Figure 1 show the experiment set up before running the experiment.

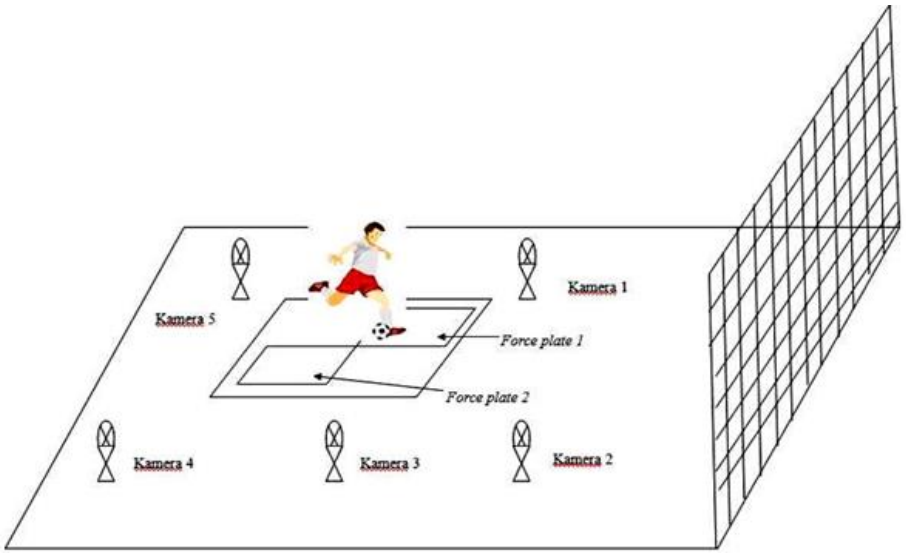

Figure 1: Experiment set up within the lab.

Activity

Each subject was required to do 18 kicks overall. As being described by the objectives, experiments started with subjects were asked to perform the kicking by applying the 1 step running and the technique of instep kicking. Each type of arrangement in this experiment will be repeated 3 times to obtain average values. Experiments continued at which the subjects were required to perform the instep kicking as well as applying the 2 steps and 3 steps running. In this study, 16 markers were attached to each subject in certain parts of

their bodies at the lower limb. The subjects perform light exercise or warming up to avoid from the occurrence of injury. 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.

III. RESULTS

Table 1 present the results of all the Taguchi analysis which it display the optimized kicking forces required for the subjects with right dominant leg. This study found that the maximum optimized force undergone in three-step run as much as 1662 N. From this study also, it shows that the kicking forces increases with each additional running steps. The analysis shows that the controlled parameters do influence the factor of kicking force for every step of running and leg dominance.

Running steps	Optimized parameters			Optimized kicking force (N)	S/N ratio
	Velocity(m/s)	Contact time (ms)	Mass (kg)		
1 step	13.8	9.5	13.73	1177	61.41
2 steps	12.4	9.0	10.26	1544	63.77
3 steps	12.4	9.0	10.26	1662	64.41

Table 1: Results of the kicking forces for the right dominant leg subjects.

Table 2 shows the summary of results for the percentage of contribution of the control factors for the right dominant leg. In addition, it is clear to say that the velocity factor of the ankle are the factors that most affect the competitive aspects of the kicking other than the contact time factor and the mass of the leg segments of the dominant leg. This can clearly be seen from the analysis of variance (ANOVA) where the percentage of contribution of the ankle velocity factor is dominant for each case of this experiment. This is in line with theory as stated by Barfield et al. (2002), which is to get the shots where the ball can be launched at the time, so the ankle velocity parameter should be maximized as well. Contact time factor and the mass of the foot segment were seen did not give any significant influence on the competitive aspects of the shots.

Parameters	Percentage of contribution (%)		
	1 step	2 steps	3 steps
Ankle velocity	85	88	94
Contact time	14	2	1
Mass	1	10	5

Table 2: Summary of results for the percentage of contribution of the control factors for the right dominant leg.

IV. CONCLUSION

As we have discussed in previous chapters, the objectives of this study were to investigate the aspects of kicking performance of Malaysian footballers. This had been realized by examining aspects of the resulting kicking forces, especially when the impact occurred at the time of contact between the ball and the leg. This study also puts a number of other factors as the objectives and analyzes the influence of these factors to the resulting kicking forces. Other factors are the type of running whether it was one A.R. Ismail, M.F.M. Ali, B.M. Deros and M.B.M. Azmin step, two steps or three steps and the factors of the dominant leg of the soccer players. From the Taguchi analysis that was carried out, it was found that the optimized force for the subjects is 1177 N. The two steps and three steps were each given a value of 1544 N and 1662 N, respectively. For subjects with dominant right leg, kicking force increased significantly with each addition of step. In addition, it is clear to say that the velocity factor of the ankle is the factor that most affect the competitive aspects of the kicking other than the time factor and the mass of the contact segments dominant leg.

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