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Moderate Effort Instep Kick in Futsal

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Abstract

In futsal matches players do not perform maximum kicking effort all the time. There are situations when the player needs to perform a moderate effort kick to achieve certain kicking objectives. In instep kicks, the kicking leg's ankle condition is one of the important parameters influencing the quality of the kick. In maximum effort instep kicks, ankle rigidity is associated with successful kicking effort. This study was focused on the kicking leg's ankle influence on ball velocity during moderate effort kicks in futsal. The focus was on the ankle condition at pre and post impact phase between the foot and the ball. Video analyses were performed on trials of the instep soccer kick with moderate effort to produce low foot velocity during kicking. Seven (n=7) skilled futsal players were selected to perform the kick. Test subject's motions during kicking trials were analyzed by the motion analysis package, Kinovea. The raw data of displacement obtained from the video analysis were then filtered by a single cut-off frequency using 4th order low-pass zero-phase-shift Butterworth filter at 11Hz. Velocity of the ankle and foot before the foot-ball impact and also the ball velocity after the foot-ball impact were calculated from the filtered data using the finite (forward) difference method. Results showed that the ankle influenced kicking outcome. This study also indicated that players focused less on ankle rigidity during ankle-foot plantar flexion during moderate effort kicks. This was based on low ankle-foot velocity ratio prior to ball impact and low coefficient of restitution as compared to maximum kick effort.

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Keywords: impact; instep kick; coefficient of restitution; correlation

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1. Introduction

Instep kick is one of the most popular and important skills in soccer. Soccer players utilize the instep kick skill in many situations such as short and long distance passes and penalty kicks. Many previous studies had focused on maximum effort instep kick biomechanics. It was reported that high ball velocity was associated with higher foot velocity during a kick approach, which was observed to be about 16-22 m/s (Zernicke and Roberts, 1978; Nunome et al., 2006; Li, 2012). However, very few studies have been conducted on futsal. Futsal is a 5-a side sports that is very similar with soccer. It is usually played in an indoor arena, on either an artificial grass or synthetic court.

In a futsal game, a variety of kicking efforts is an important factor as soccer player are required to perform a balanced mixture of slow, moderate and maximum kicking effort throughout the game. The study by Li (2012) on the soccer instep kick indicated that ankle movement influenced kicking outcome for maximum effort. This is attributed to the complicated relationship between ankle and feet in performing plantar flexion during the kick. It was suggested that in order to achieve good kicking quality, the ankle should be in a rigid condition during the foot-ball impact phase. This will influence the ball velocity after impact. However, in a slow or moderate kick effort, achieving maximum ball velocity is not always the ultimate objective. Therefore, this study was primarily focused on the relationship between ankle velocity prior to the foot-ball impact with other kicking and impact quality indicators, and on how ankle velocity correlates with those parameters.

Kicking performance is dictated by the foot-ball interaction (Nunome et al., 2006). This impact phase is influenced by how the kicking leg's foot and ankle behave during kicking. In the kicking situation prior to the foot-ball impact, the foot's lateral part will be in plantar flexion position. Plantar flexion positioning is determined by the joint ankle movement. Therefore it is important to understand the ankle behaviour during kicking, especially during foot-ball impact phases. Rigidity of the ankle during impact phase is also critical in kicking outcome for maximum effort kicks (Li, 2012). This study was designed to observe the kicking leg's ankle and foot kinematic aspects prior to the foot-ball impact and how it correlates with each parameter studied.

2. Method

2.1 Test subjects and materials

The test subjects for this study were seven (n=7) skilled male amateur futsal players. The test subjects' mean age was 21 ± 1 year. The test subjects height and mass were 1.71 ± 0.06 m and 71.5 ± 13.50 kg, respectively. During the kicking session, all test subjects wore standard futsal shoes and socks with a combined mass of between 0.28 to 0.32 kg. In order to reduce the shoe effect on the kick, all subjects were required to wear the same type and model of Admiral futsal shoes (CTL-5TF; for artificial grass court), with sizes ranging from 7 to 9 (UK). A size-4 ball with a mass of 0.39 kg at inflated pressure in the range of 60-80 KPa was used in the study.

2.2 Experimental setup

The study was conducted at an indoor futsal arena. A 0.20 m height with 0.10 m diameter range target (a small cone) was assigned for the test subjects to hit with the ball. The ball was placed 15 m perpendicular from the target. Two video cameras (Casio EX-ZR100) with the capability to set at 240 frames per second (240 Hz sampling rate) were placed 0.50 m perpendicular to the side and front of the ball location. The distance of the centre of the camera lens to the ground was set at 0.25 m height using a mini tripod.

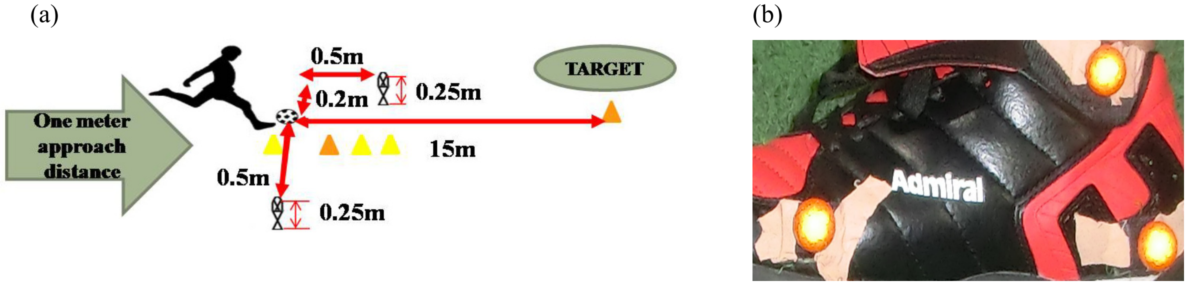

Fig. 1. (a) Experimental setup (b) 0.012 m diameter low diffuse reflective markers

The video cameras was set to capture the test subject's shank to foot area and was also set at an angle wide enough to record the ball movement after the foot-ball impact phase. The test subjects were required to stand 1 m from the ball location. This will be the starting point where the test subject will start the kicking approach of the ball. The subjects were requested to perform a moderate approach and kick the ball with instep technique and the task is to hit the assigned target in front of them. The ankle- foot joint movements are digitally tracked using Kinovea (v.0.8.15) by tracking the low diffuse reflective markers (0.012 m diameter size) as illustrated in Fig 1. A 0.013 m diameter reflective tape was attached on the side of the ball's centre facing the side camera.

2.3 Data collection

Based on the experimental setup, test subjects were requested to perform 3 trials of moderate approach (not maximal) and kick the ball, which was in a stationary condition, with instep technique towards the assigned target.

With the video cameras in the recording mode, test subjects will pause for 5 seconds before approaching the ball. The recording mode of the camera will be switch off after the ball moves near or passes the target. By capturing the side and front view of the kicking effort, accurate coordinates of the joints and ball movement are obtained.

Data collected during the video analysis was then processed by motion analysis software (Kinovea, version 0.8.15). Here, the recorded video will be viewed frame by frame for the whole time duration of the kicking trials. Initially, the recorded video was calibrated vertically and horizontally to meet with the real world measurement. Using Kinovea's path tracking, the movements of the joints of interest during the kicking duration were digitally tracked (Fig. 2). The software tracking mode was set to track the movement of the test subject's ankle and fifth meta-tarsal on the kicking leg (Nunome et al., 2006) and also track the ball movement between 0.06 to 0.24 seconds before and after the foot-ball impact. Thus, the displacements for each of the areas of interest were obtained. Initial raw data will be the coordinates of the tracked points (X-axis, Y-axis and Z-axis i.e vertical, horizontal and depth coordinates) for each video frame recorded with respect to the initial coordinates assigned at the early stage of the tracking mode setting. These coordinates for each frame were obtained by calculating the average value of the 3 markers located between the ankle and the fifth meta-tarsal. The ball positions were tracked based on the reflective tape attached onto it. These coordinates were then numerically solved to obtain the displacement data, using the following equation:

$$D = \sqrt{(x_n - x_{n-1})^2 + (y_n - y_{n-1})^2 + (z_n - z_{n-1})^2} \qquad (1)$$

where D is the distance of tracked points between each frame.

The values x_n, y_n and z_n are the coordinates of the tracked point and x_{n-1}, y_{n-1} and z_{n-1} are the coordinates of the previous tracked point. Since the video was recorded at 240 Hz, each frame will have a sampling rate at 0.004 seconds.

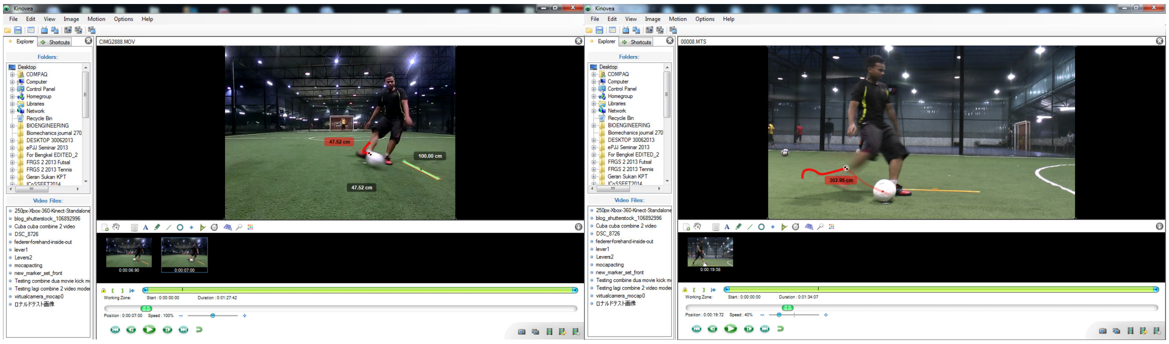

Fig. 2: Video analysis with Kinovea

2.4 Data filtering

The displacement data obtained from the motion analysis software were then filtered by a low-pass Butterworth filter (Giorgakis et al., 2002; Erer, 2007; Winter, 2009; Katis and Kellis, 2010). The algorithms of these Butterworth filters were adopted from techniques presented by Giorgakis et al. (2002) and Erer (2007). The best cut-off frequency for the filter was estimated to obtain the best curve line. The frequency was initially set from between 6-48 Hz in the trial and error stage, but eventually it was found that the frequency at 11 Hz represented the best results. In this study, frequencies below and above 11 Hz did not produce the desired data smoothing effect (Ismail et al., 2013).

2.5 Velocity calculation

The filtered data was then used to calculate the parameter's velocities using the finite (forward) difference method provided in the following equations:

$$v = \frac{\Delta D}{\Delta t} \tag{2}$$

and

$$\frac{\Delta D}{\Delta t} = \frac{D_n - D_{n-1}}{t_n - t_{n-1}} \tag{3}$$

where v is the velocity, ΔD is the change in displacement and Δt is the change in sampling time.

3. Results

The results obtained from this study are presented in Tables 1 and 2. All descriptive statistics were calculated using IBM SPSS Statistics v.20 package. Correlation analysis was performed using Pearson's correlation.

Table 1. Factors related to ankle velocity during instep kick and their respective correlation coefficients.

VARIABLE	(n)	MIN.	MAX.	MEAN	SD	(r)
Ankle Velocity (before impact) [m/s]	7	11.20	13.58	12.17	0.89	-
Foot Velocity (before impact) [m/s]		14.15	16.52	15.47	0.95	0.63
Foot Velocity (after impact) [m/s]		10.07	12.95	11.52	1.05	0.59
BallVelocity (after impact) [m/s]		12.30	16.46	14.54	1.34	0.68
Ball Velocity (after impact) - Foot Velocity(before impact) Ratio		0.86	1.03	0.94	0.06	0.37
Ankle Velocity (before impact) - Foot Velocity (before impact) Ratio		0.73	0.85	0.79	0.05	0.59
Coefficient of Restitution during impact		0.15	0.27	0.20	0.04	0.27

Table 2. Overall correlation coefficients during moderate instep kick.

	AVB	FVB	FVA	BVA	BFVR	AFVR	COR
Ankle Velocity (before impact) [m/s] (AVB)	-	0.63	0.59	0.68	0.37	0.59	0.27
Foot Velocity (before impact) [m/s] (FVB)	0.63	-	0.47	0.76*	0.14	-0.25	0.53
Foot Velocity (after impact) [m/s] (FVA)	0.59	0.46	-	0.80*	0.75	0.22	-0.09
BallVelocity (after impact) [m/s] (BVA)	0.68	0.76*	0.80*	-	0.75	0.05	0.52
Ball Velocity (after impact) - Foot Velocity(before impact) Ratio (BFVR)	0.37	0.14	0.75	0.75	-	0.31	0.25
Ankle Velocity (before impact) - Foot Velocity (before impact) Ratio (AFVR)	0.59	-0.25	0.22	0.05	0.31	-	-0.18
Coefficient of Restitution during impact (COR)	0.27	0.53	-0.09	0.52	0.25	-0.18	-

*. Correlation was significant at the 0.05 level. ($p < 0.05$)

4. Discussion

The results from this study indicated that ankle velocity prior to foot-ball impact during moderate effort instep kick was less significant when compared to foot velocity in relation to the post ball velocity. Prior to the foot-ball impact, ankle velocity was less incremental when compared to foot velocity. Here, it was observed that the average ankle velocity was 21% lower than the foot velocity during pre impact. This showed that lower post impact's ball velocity in moderate effort kicks were influenced by the ankle velocity prior to the impact. It is well known that a low coefficient of restitution during impact will produce a low post impact ball velocity. However, it was clear whether low coefficient of restitution resulted from low ankle velocity prior to impact, because the data analyzed were not focused on the impact's exact moment. If we numerically solve the coefficient of restitution in the modeling equation (Lees and Nolan, 1998), we would obtain a coefficient of restitution well below 0.3 that will result in a ball velocity after impact-foot velocity before impact ratio to be less than 1. It was reported that for maximum effort instep kick, the coefficients of restitution were between 0.46 and 0.68 (Anderson et al., 1999). If we assume that the maximum velocity prior to ball impact is equal to the velocity during ball impact, we would obtain a coefficient or restitution during moderate velocity in this study to be around 0.2 to 0.3. Also, in this study the ball velocity after impact-foot velocity before impact ratio was 0.94. In a previous study by Anderson et al. (1999), it was reported that this ratio was around 1.2 for maximum effort. It is believed that during moderate effort kicks, players do not fully plantar flex the ankle-foot joint, resulting in a lower ankle and foot velocity (Sterzing and Hennig, 2008). A low coefficient of restitution and low ankle-foot velocity ratio prior to the ball impact are indicators that the ankle rigidity was low during ankle-foot plantar flexion prior to foot-ball impact during moderate effort kicks. This study also indicated that there was no significant correlation between the coefficient of restitution and ball velocity, as reported by De Witt and Hinrichs (2012).

5. Conclusion

The results of the study indicated that foot velocity prior and post foot-ball impact were major factors, regardless of moderate or maximum effort kicks. Since the ankle velocity was low during moderate effort kicks, it does not significantly influence post impact ball velocity. The value of ankle-foot velocity ratio prior to ball impact and coefficient of restitution during moderate effort kicks indicated that ankle rigidity level was low during the impact phase. This showed that less effort was focused by the players to increase ankle rigidity during ankle-foot plantar flexion stage prior to foot-ball impact when performing the instep kick with moderate effort.

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