A KINEMATIC INVESTIGATION OF MAXIMAL FORCE INSTEP KICK WITH ARM SWING ON SOCCER

1Yo Chen and 2Jia-Hao Chang

1 Department of Physical Education, National Taiwan Normal University, Taipei, Taiwan; email: luxman1227@yahoo.com.tw
2 Graduate Institute of Exercise and Sport Science, National Taiwan Normal University, Taipei, Taiwan

SUMMARY
Purpose: To understand the kinematic characteristic on instep kick with arm swing. Method: An elite football player (age: 25 years-old) participated in this experiment. The VICON MX13™ motion capture system with 10 cameras (250Hz) was used to collect kicking data of instep kick with arm swing and arm fixed. The STALKER radar gun (300 Hz) was used to measure the peak ball velocity. The Visual3D software was used to calculate the kinematic parameters of instep kick. Results: Kicking with arm swing had the higher ball velocity (swing: 96.87 ± 2.03 Kmh; fixed: 93.00 ± 1.41Kmh) and kicking foot velocity (swing: 13.60 ± 1.07 m/s; fixed: 13.01 ±0.61 m/s). The trunk was more upright (swing: 10.72° ±2.60; fixed: 15.28° ± 0.66) and the greater lean angle on support foot on instep kick with arm swing (swing: 28.85° ± 1.63; fixed: 24.79° ± 0.79). The greater lean angle of support foot provides the more space and longer level of kicking leg to kick a ball. Conclusion: Kicking with arm swaying increased the lean angle of support foot, foot velocity, and ball velocity.

INTRODUCTION
Many biomechanical researches of soccer try to understand the kinematic and kinetic effects of kicking; the most widely concerned is maximal force instep kick (powerful instep kick). Kicking is a natural fluid motion and a fundamental activity in soccer [3]. A study reported that the ball velocity in instep kick on related researches were ranged from 72 Km/h (20m/s) to 115.6 Km/h (32.1 m/s) [4]. The kicking skills are complicated, and multiple factors must be measured [5]. Kicking with arm swing is a common motion on goal kick, directly free kick, penalty kick, and instep kick. The arm (non-kicking side) begins to swing when a player run-up to kick a ball at the last step and it may provide more strength to kick a ball. Arm swing motion also applies in other sports. It advances the jumping performances in standing long jump due to maintaining balance and increasing the velocity of the body’s center of gravity [1].

Skilled soccer players had the more ball velocity and the less trunk angle of lean and inclination [6]. The foot velocity of kicking leg and ball velocity on instep kick are the important parameter for understanding the skill of players. The support foot orientated the ball direction and adjusted the altitude of ball flight [2]. The precise position of support foot can provide more place for plantar-flexion on kicking foot. To improve the kicking ability, the purpose of this study was to find the kinematic characteristic on instep with arm swing. The kinematic differences were compared the arm swing and arm fixed during instep kick.

METHODS
An elite football player played in national team (age: 25 years-old, height: 175 cm, weight: 80 Kg, kicking with right foot), without lower extremity injuries volunteered to participate in this study. A self-selected approach angle (Figure 1) and step (30 degree, 2 steps) by participant were used in this study, which would allow a maximal instep kick.

Figure 1: Approach angle

Figure 2: Arm swing and fixed (R)

A motion capture system with 10 cameras (sampling at 250Hz, VICON MX13™, Oxford Metrics Ltd, England) was used to capture the kicking motion. A radar gun (sampling at 300 Hz, STALKER Ltd, USA) was used to measure the peak ball velocity (FIFA approved Adidas soccer ball, model: final8, size: 5, Pressure: 0.6 bar). The plug-in-gait marker set were use to build full-body model.

Arm swing motion includes shoulder flexion and abduction, the participant was asked to swing the non-kick side arm than kick the ball at the last step (Figure 2 L). The kicking with arm fixed was to fix the arm on hip (kicking with arms akimbo, Figure 2 R) than kick the ball. The subject was asked to kick 10 times in each task into the target net with maximal force instep kick. (width: 1m and height: 0.8 m, the distance from ball to target net was 1.5 m).

The Visual3D V4.0 software (C-motion Inc, USA) was used to calculate the foot velocity, distance between right (R) and left (L) heel, and the trunk and support leg lean angle on frontal plane posterior view while the foot and ball contact. The descriptive analysis was used to analyze kinematic data.
RESULTS AND DISCUSSION
The results of the R and L heels distance, the trunk and support foot lean angle, and the ball and foot velocity are shown in Table 1. The range of ball velocity on arm swing was 94~100 Km/h, and arm fixed was 90~95 Km/h (Figure 3). The instep kick with arm swing had the greater R and L heels distance, support foot lean angle, foot velocity, and ball velocity.

![Figure 3: The range of ball velocity with arm swing and fixed](image)

The literatures indicated that the arm motion provides more strength in instep kick, but they didn’t compare kicking with arm swing. In this study, the lean angle of support foot was 28.9° (arm swing) and 24.8°; and the ball velocity was in different trend. The arm swing motion affects the lean angle of support foot, foot velocity, and ball velocity; due to it provides more moment arm of kicking leg to kick a ball. The related study reported that the lean angle 20.6° and 27.4° of support foot didn’t affect the ball velocity [7]. However, the ball velocities were different between kicking with arm swing and arm fixed in this study. This might be affected by the different lean angle of support foot. The greater lean angle of support foot provides the more space to stretch the foot for full plantar-flexion to kick the ball. Arm swing may adjust the trunk position while kicking with arm swing, the trunk still had the more upright position (swing: 10.72° ± 2.60; fixed: 15.28° ± 0.66).

CONCLUSIONS
Kicking with arm swing had the greater R and L heels distance, lean angle of support foot, foot velocity, and ball velocity. The greater lean angle of support foot may provide more moment arm of kicking leg to kick a ball. It had the more space to stretch the foot for full plantar-flexion to kick the ball. Arm swing affected the posture on instep kick, the trunk was maintain the more upright position while kicking with arm swing. Future studies could describe the functions of arm swing during instep kick on motor control perspective.

REFERENCES

Table 1: The ball and foot velocity and the trunk and support foot lean angle.

<table>
<thead>
<tr>
<th>Arm motion</th>
<th>R and L heel distance (cm)</th>
<th>Trunk lean (degree)</th>
<th>Support foot lean (degree)</th>
<th>Foot velocity (m/s)</th>
<th>Ball velocity (Km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm swaying</td>
<td>25.40 ± 1.82</td>
<td>10.72 ± 2.60</td>
<td>28.85 ± 1.63</td>
<td>13.60 ± 1.07</td>
<td>96.87 ± 2.03</td>
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<tr>
<td>Arm fixed</td>
<td>21.20 ± 1.58</td>
<td>15.28 ± 0.66</td>
<td>24.79 ± 0.79</td>
<td>13.07 ± 0.61</td>
<td>93.00 ± 1.41</td>
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