THE KINEMATICS CHAIN OF INSTEP KICKING OF SOCCER WITH UPPER-BODY CONSTRAINED: A PILOT STUDY

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The purpose of this study was to understand the kicking performance when the upper-body motion has been limited. One player in the college cup level A volunteered to participate in this study (Aged: 20 years, Height: 172 cm, Body mass: 65 kg). A VICON motion capture system (200 Hz) was used to capture the kicking motion. The participant was asked to kick the ball both using an arm swing and not using an arm swing. The Visual3D was used to calculate the segment velocity, angular velocity, and kinetic chain. The results indicated that kicking with arm swing had a greater ball and lower-extrimity segment velocity. The main effect for lower ball velocity during kicking without arm swing is the decreased angular velocity at the ankle joint. When arm motion has been limited, players should noticed that the ankle joint needs to follow through after foot-ball contact.

KEY WORDS: Football, goal, shooting, lower-extremity, powerful-kick.

INTRODUCTION: Instep kicking is fundamental in soccer. Many studies have been demonstrated the characterastics of instep kicking and compared the kicking biomechanics in different levels of players or different ways to kick a ball. However, in real competition, players may have confined by timing or a defender to stretch the body to kick a ball. Ball (2008) found that different arm motions affect kicking performance in Australian football. The foot velocity and ball velocity are the main parameters to understand the kicking performance. Meanwhile, the transit of segment motion also plays an important role in kicking. Dorge et al. (2002) indicated that a better inter-segmental motion patterns can transfer a greater velocity from the segments of the lower-extrimity to the ball. Thus, the purpose of this study was to understand the kicking performance when the upper-body motion has been limited. The segment velocity, angular velocity, and kinematic chain were used to understand the performance between different upper-body motions when kicking a ball.

METHODS: A player in the college cup level A volunteered to participate in this study (Aged: 20 years, Height: 172 cm, Body mass: 65 kg, 8 years experience). The participant had no injuries within the last 6 months. This experimental protocol was approved by the Research Ethics Committee of National Taiwan University. A motion capture system with 10 cameras (sampling at 200 Hz, VICON MX13^{+}, Oxford Metrics Ltd, England) was used to capture the kicking motion. The Noraxon foot-switch (Noraxon Inc. U.S.A) was used to measure the timing of foot-ball contact. A radar gun (sampling at 300 Hz, Bushnell Ltd, USA) was used to measure the peak ball velocity (Adidas Final8, size 5, Pressure: 0.6 bar). The participant was asked to swing the arm and not swing the arm during five maximal force instep kicks. The data chosen to analyze was the data from the trial with the greatest ball velocity. The plug-in-gait marker setting was used to build a full-body model. The Visual3D V4.0 software (C-motion Inc, USA) was used to calculate the segment velocity, angular velocity, ball velocity, and kinetic chain. A descriptive analysis was used to analyze the data.

RESULTS: Table 1 shows greater ball velocity and foot velocity was found in kicking with arm swing. Figure 1 is the kinetic chain of segment velocities, and Figure 2 is the kinetic chain of angular velocities. The greater segment velocities in the thigh, shank, and foot were found in kicking with arm swing, but the greater angular velocities were found in kicking without arm swing. During kicking with arm swing, the time for kinetic chain connection was 0.045 s from the peak thigh velocity to the peak shank velocity, and 0.025 s from peak shank

velocity to the peak foot velocity. When kicking without arm swing, the time was 0.04 s and 0.03 s, respectively.

Table 1
Velocities between kicking with and without arm swing when foot-ball contact

	Arm swing	Without swing
Ball velocity (m/s)	33.6 (93 Km)	31.8 (88 km)
Foot velocity	15.0	14.5
Shank velocity	8.9	8.6
Thigh velocity	3.2	3.0
Ankle angular velocity (s/deg)	-331.8	-281.7
Knee angular velocity	1186.8	1238.1
Hip angular velocity	341.1	366.8
Run-up velocity (m/s)	3.3	3.1

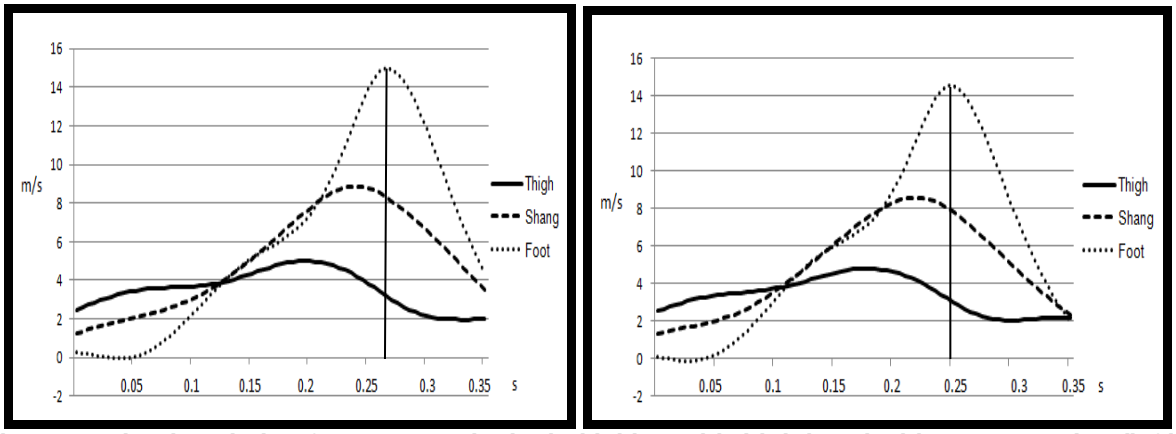

Figure 1: Kinetics chain of segment velocity in kicking with (right) and without arm swing (left), the vertical line is the foot-ball contact point

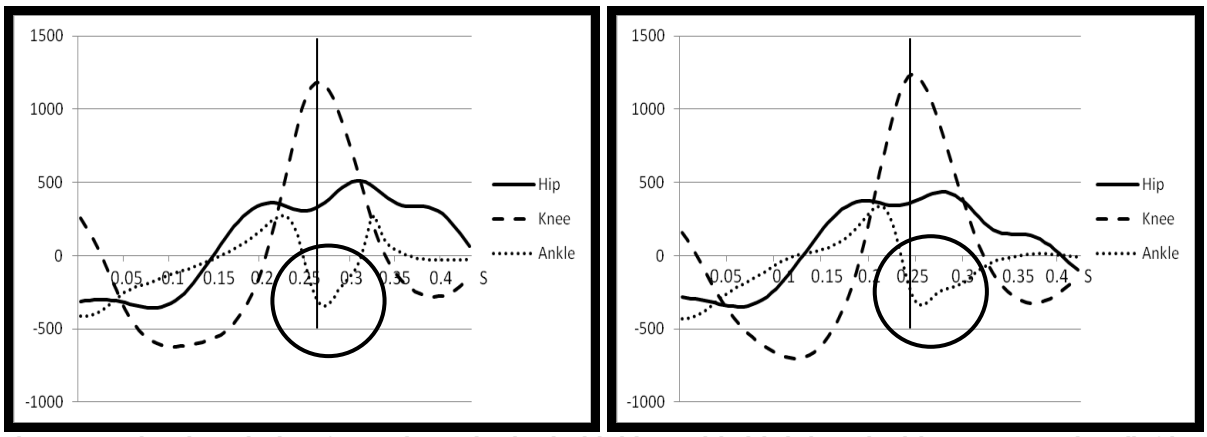

Figure 2: Kinetics chain of angular velocity in kicking with (right) and without arm swing (left), the vertical line is the foot-ball contact point

DISCUSSION: The similar pattern in kinematic chain of segment velocity was found in this study. Kicking with arm swing had a greater thigh, shank, and foot segment velocity, and it causes the greater ball velocity after foot-ball contact. According with the previous study of Dorge et al. (2002), the knee angular velocity is the determining factor of kicking performance. Our study also found the importance of the knee angular velocity. The foot-ball contact point was the timing in the peak value of knee angular velocity (Figure 2). Although the kinematic chains look alike, there is another key factor affecting ball velocity. In figure 2, when kicking with arm swing, the ankle angular velocity increased more than kicking without arm swing after ball contact. This condition may be caused by the foot and ankle joint not completing the kicking task in the following phases when kicking without arm swing, and the

force transmission to the ball may reduced because the ankle joint absorbed the force of kicking. The greater knee angular velocity was found in kicking without arm swing, but it did not produce the greater foot segment velocity.

CONCLUSION: This study identified that kicking with arm swing had better kicking performance. In real competition, if the arm motion has been limited, players should notice that the ankle needs to follow through the kicking motion after foot-ball contact.

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