THE EFFECT OF KICKING DIRECTION ON SOCCER INSTEP KICKING KINETICS

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SUMMARY
Instep kicking is a fundamental technique in soccer. In match situation, players have to kick the ball to various directions. Although several studies focused on such conditions, Kinetic parameters, such as joint torque, has not been clarified. The purpose of this study, therefore, was to illustrate the effect of kick directions on soccer instep kicking kinetics. Nine experienced male soccer players performed instep kicks on three conditions to change the kicking directions (15, 45 and 75 degrees to the kicking direction). Their kicking motions were captured using electrically synchronized four high-speed video cameras at 250Hz. Three dimensional joint torque and angular velocity of swing leg (hip and knee) were calculated. The general patterns of joint torque and angular velocity were similar during each condition (AP15, AP45, and AP75). Absolute foot velocity at immediately before ball impact was sufficiently accelerated, and has not significant differences during three conditions. It was suggested that players who participated in this study achieved a well-coordinated kicking motion, even if they were required peculiar technique to kick to angled direction. In addition, player kicks the ball to angled direction, larger hip addiction torque act to control the hip abduction motion.

INTRODUCTION
Instep kicking is a fundamental technique in soccer. Previous studies have examined three dimensional motions of that kicking, and the kinetic parameters of the swing leg have been clarified [4,5]. However, these studies exclusively focused on the motion when the player kicks the ball to one certain direction (towered goal). In match situation, players have to kick the ball to various directions. Changing those directions is attributed to change the angle between approach and kicking direction. Although several previous studies have examined the effect of approach angle on soccer instep kicking [2,3,6], the three dimensional kinetics, such as joint torque, have never been investigated. The purpose of this study was to illustrate the effect of kick directions on soccer instep kicking kinetics.

METHODS
Nine experienced Japanese male soccer players (hight : 172.4±6.5 cm, weight : 62.3±5.9 kg, age : 19.4±0.7 year, career : 11.6±2.8year) were volunteered to participate in this study. They performed instep kicking using their preferred leg (All subject preferred right leg) on three conditions to change the kicking directions. Those three conditions were decided to angle between kick direction and approach directions (15, 45 and 75 degrees; Here after AP15, AP45 and AP75, respectively). The three conditions were performed in a randomized order. Furthermore, each subject was instructed to kick with maximum effort, toward the center of target (0.8m×0.8m), which placed at 3m ahead. Their kicking motions were captured using electrically synchronized four high-speed video cameras at 250Hz. A digitizing system was used to digitize manually skin markers, which were attached to several body landmarks. The three dimensional coordinate of each markers was reconstructed using the direct liner transformation (DLT) method.

Angular velocity of right lower leg (foot and shank), right thigh and pelvis were calculated from local reference frames fixed on each segment. According to the procedures applied in the previous studies [1,4,5], joint torques (hip extension/ flexion, adduction/abduction, internal/external rotation, knee extension/flexion, internal/external rotation) were computed using two link segment model composed with the lower leg and thigh.

The time-series data were digitally smoothed by a forth- order Butterworth filter at 12.5Hz. To avoid systematic distortion due to ball impact, subsequent data of impact was extrapolated before smoothing and then extrapolated region was removed after smoothing. Finally kick motion from the toe of the kicking (right) leg to ball impact was normalized to 100% [4].

RESULTS AND DISCUSSION
There was no distinct change for the changing patterns of segmental angular velocities in all conditions (AP15, AP45, and AP75). Likewise, the general patterns of joint torque (figure 1, 2) were also similar between the conditions. During kicking (from toe off to ball impact), hip flexion, addiction, external rotation, knee extension torques were mainly appeared. The change of knee internal/external rotation torque was small enough to be negligible. Those results almost correspond to those in previous studies regarding the normal instep kick towered goal (did not instruct approach angle) [4,5]. It was indicated that kicking direction had no appreciable influence on the general exerting pattern of hip and knee joint torque. Previous study focused on difference between of prefer leg and non-prefer leg, and had been discussed the mechanism for accelerating the lower leg of swing leg [5]. This result was concluded that if players already

achieve a reasonable inter-segmental coordination, the muscular force (knee extension muscle torque) would be the main determinant for the faster leg swing. In present study, although the peak magnitude of knee extension torque (muscle torque) was significantly lower in the AP75 than that in the AP15, no significant differences were observed between the two conditions for the absolute foot velocity immediately before ball impact (AP15: 18.4±1.0 m/s & AP75: 18.8±0.9 m/s). From these results, it was suggested that players who participated in this study achieved a well-coordinated kicking motion, even when they were required to kick the ball to very angled direction.

Nunome et al. [4] suggested that the hip adduction torque probably acts to control the hip abduction which is produced the motion dependent interactions produced by an angled approach run and pelvis rotation. In the present study, the larger kicking angle, the higher angular impulse of hip abduction (AP15: 8.3±2.8 Nm・s, AP45: 10.1±2.6 Nm・s AP75: 12.1±3.1 Nm・s) was indicated, and the peak of the AP75 was significantly higher than that in the AP15. Faster pelvic rotation was used by players when they kick the ball to large angled direction. This motion likely facilitates the body to face the kicking direction, thereby emphasizing the centrifugal force acting on the swing leg. It was assumed that the larger hip adduction angular impulse observed in AP75 has a role to maintain the swing leg angle against the centrifugal force.

CONCLUSION

The present study clarified the joint torque of swing leg to illustrate the effect of kick directions on soccer instep kicking kinetics. Kicking direction doesn't exert general pattern of hip and knee joint torque. As player kick the ball to angled direction, larger hip addiction torque act to control the hip abduction motion.

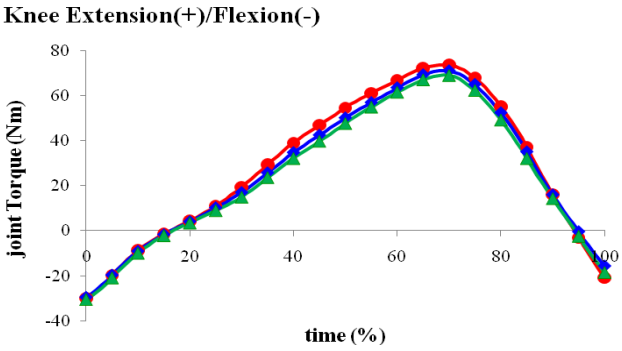

Figure 1: Changes in the joint torque of knee (extention/frexion). Line with marker (●, ◆, ▲) indicated AP15, AP45, AP75, respectvely.

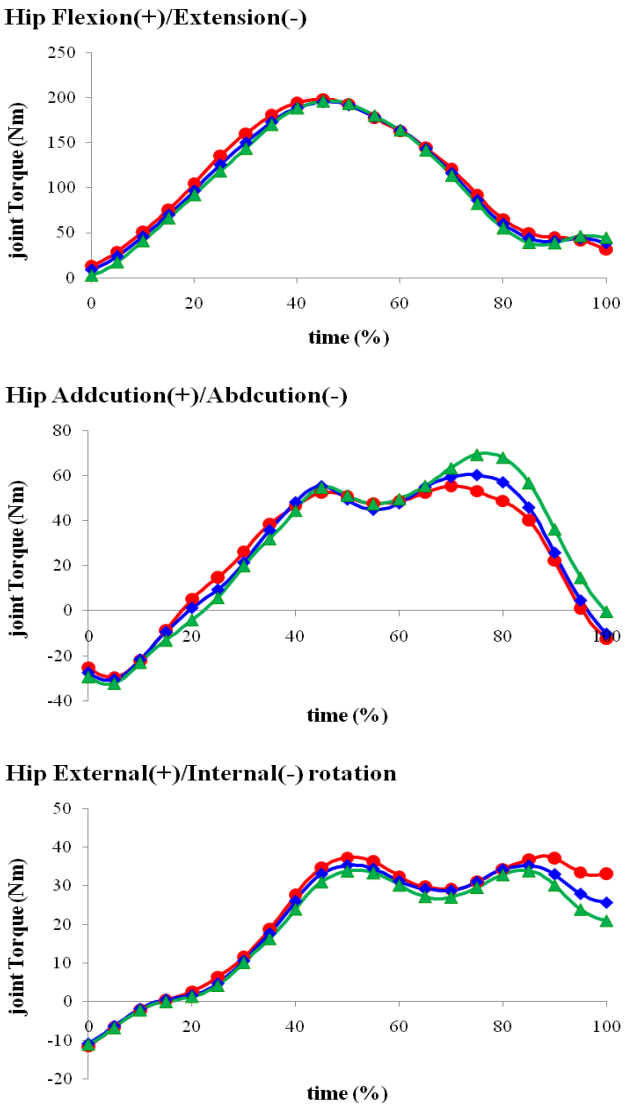

Figure 2: Changes in the joint torque of hip (top: flexion/extension, middle: addiction/abduction, bottom: internal/external rotation). Line with marker(● , ◆ , ▲) indicated AP15, AP45, AP75, respectvely.

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