POWER AND WORK DUE TO JOINT TORQUE DURING IN-SIDE AND IN-STEP SOCCER KICKS

H. Nunome 1, Y. Ikegami 1, T. Asai 2, S. Sakurai 1, T. Terashima 3
1 Research Center of Health, Physical Fitness & Sports, Nagoya University, Nagoya/Japan
2 Faculty of Education, Yamagata University, Yamagata /Japan
3 Cyukyo University, Toyota/Japan

Introduction
Among many forms of kicking, the in-side kick is the most frequently used when a shorter and precise pass or shot is required, while the in-step kick is used when a faster ball speed must be generated. However, as most kinetic data related to soccer kicks are limited to quasi-planar analyses of the in-step kick, it is necessary to identify the three-dimensional aspects of the kicking motion to understand the true kinetics. The purpose of this study, therefore, was to quantify the three-dimensional kinetics of in-side and in-step soccer kicks by examining the aspects of power and work due to joint torque.

Methods
Informed consent was obtained from five male high-school players (height = 174.6 ±4.9 cm; weight = 67.6 ±4.8 kg) who volunteered to participate in this study. After a short period of warm-up, they were instructed to perform in-step and in-side kicks, with maximum effort, to the center of goal, which was located at a distance of 11 m in front of them. A regulation soccer ball (FIFA standard) was used. Three trials were employed for each kick and two electrically synchronized high-speed video cameras (NAC Inc., Tokyo, Japan) were used to sample the kicking motion at 200 fps (shutter speed was 1/2000 s) from the rear and kicking leg (right) side. The direct linear transformation (DLT) method was used to obtain 3-D space coordinates of the trunk and the kicking leg. The time dependent coordinates were digitally smoothed by a second-order zero-lag Butterworth type low-pass filter at 12.5 Hz, in which the reverse order was canceled to exclude the effect of a sudden deceleration caused by ball impact. The kicking leg was modeled as a three-link kinetic chain composed of the thigh, shank and foot, and by which joint torque and joint angular velocity of each joint were calculated. Power due to the joint torque was computed for each orthogonal component by taking the product of the joint torque and joint angular velocity.

Results & Discussion
The power curves showed several similarities between the two kicks (Figure 1), in which 0 % and 100 % of the time corresponding to right toe take-off and ball impact, respectively. In both kicks, the largest positive power was observed by the hip flexion torque during the middle to latter part of the kicking, and the power due to knee extension torque subsequently became positive near ball impact. On the other hand, a remarkable difference was found between the two kicks for the power due to hip external rotation torque. The positive power due to this torque was selectively observed for the in-side kick and the magnitude was comparable with that due to the knee extension torque just prior to ball impact. The positive works done by the joint torques are summarized in Table 1. The in-side kick showed significantly smaller and larger positive work due to the knee extension and hip external rota-

<table>
<thead>
<tr>
<th>Joint Torque</th>
<th>In-step M (SD)</th>
<th>In-side M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee Due to extension torque</td>
<td>28.7 (13.1)</td>
<td>12.5 (8.6)*</td>
</tr>
<tr>
<td>Hip Due to adduction torque</td>
<td>21.4 (7.6)</td>
<td>7.9 (7.4)</td>
</tr>
<tr>
<td>Due to flexion torque</td>
<td>94.2 (25.6)</td>
<td>129.0 (46.1)</td>
</tr>
<tr>
<td>Due to external rotation torque</td>
<td>3.5 (3.1)</td>
<td>32.1 (13.0)*</td>
</tr>
<tr>
<td>Total</td>
<td>147.8 (30.2)</td>
<td>181.5 (50.7)</td>
</tr>
</tbody>
</table>

*shows significant difference $p < .01$.
tion torque than those of the in-step kick, respectively. The hip external rotation torque supplied 18 % of the total positive work in the in-side kick.

These aspects of the in-side kick seem to be inconsistent with the results of angular motions reported by Levanon & Dapena (1998). In their report, players orient the pelvis, the right leg and the foot more toward to the right (for right footed player) to hit the ball with the medial side of the foot, in which no appreciable hip external rotation was recorded, in which the foot velocity is mostly produced by a series of planar motions: hip flexion and knee extension, as in the instep kick. In contrast, the result of the present study strongly suggests a significant contribution of the hip external rotation to the forward velocity of the medial side of the foot. This apparent disparities probably be exposed a different style of the in-side kick.

References

Figure 1: Average changes of selected powers due to the hip and knee joint torques in the in-step (left) and in-side (right) kicks.