THE EFFECT OF HIP LINEAR MOTION ON LOWER LEG ANGULAR VELOCITY DURING SOCCER INSTEP KICKING

Hiroyuki Nunome, Yasuo Ikegami
Research Centre of Health, Physical Fitness and Sports, Nagoya University, Nagoya, Japan

The influence of the hip linear motion on the lower leg kinetics was examined for soccer instep kicking. Five highly skilled club players volunteered and their kicking motion was three-dimensionally captured at 200 Hz. According to the procedure of Putnam (1991), the interactive moment due to the hip linear acceleration (MHLA) acting on the lower leg was extracted. The MHLA exhibited a large positive moment to increase the lower leg angular velocity during the final phase of kicking. This effective action of the MHLA was mostly caused by the upward acceleration of the hip. As the hip motion is exclusively due to the motion of the support leg, it can be assumed that the effective action of the MHLA is most likely due to the support leg motions such as the knee extension motion during kicking.

KEY WORDS: segmental dynamics, interactive motion, support leg motion

INTRODUCTION: Coordinated lower limb swing has been considered to be executed by the controlled recruitment of muscle force and segmental interactions. In several previous studies (Putman, 1991; Nunome et al., 2004), the substantial influence of the motion-dependent interactive moment has been revealed on several typical proximal-to-distal sequences of limb segment motions including soccer instep kicking.
Although the procedure established by Putman (1991) allowed the interactive moments due to the hip linear motion to be computed, its influence on the lower leg swing has attracted relatively little attention from researchers. Inoue et al., (2000) was the only study which focused on the effect of the hip vertical lift on the leg swing speed in soccer instep kicking. In their study, a greater upward lift of the hip was observed for the skilled players and its positive effect on the final foot velocity was confirmed by a computer simulation. However, the time-series action of the interactive moment due to the hip linear motion has not been illustrated.
In the present study, an attempt was made to extract the influence of the hip linear motion on the lower leg swing using the procedure of Putnam (1991). The purpose of this study was, therefore, to quantify the effect of the hip linear motion on the lower leg swing during soccer instep kicking.

METHODS: Five highly skilled club players (age: = 16.8 ± 0.4 yrs; height: = 176.2 ± 6.1 cm; mass: = 70.6 ± 7.2 kg) volunteered to participate in this study. Informed written consent was obtained from each participant. After an adequate period of warm-up, the players were instructed to perform maximal instep kick, to a target located at the centre of goal a distance of 11 m ahead. All participants performed at least five attempts with the right (preferred) leg so that two shots could be selected with both a good foot-to-ball impact and an adequate centre of targeting. Two electrically synchronized video cameras were used to capture the lower limb motion at 200 Hz (exposure time was 1/2000 s). A digitizing system was used to manually digitize body landmarks including: right hip, right knee, right ankle, right heel and right toe. The centre of the ball was also digitized in its initial stationary position and in all available frames after it left the foot. The direct linear transformation (DLT) method was used to obtain the three-dimensional coordinate of each landmark.
According to the procedure of Putnam (1991), the interactive moment due to the hip linear acceleration (MHLA) was computed from a two-link kinetic chain composed of the thigh and lower leg as follows:

$$\mathbf{MHLA} = \mathbf{r}_L \times (m_L \cdot \mathbf{a}_{hip})$$

where $\mathbf{r}_L$ is a vector from the lower leg CG to the knee joint centre, $\mathbf{m}_L$ is mass of the lower leg, $\mathbf{a}_{hip}$ is the hip linear acceleration vector.
To avoid a systematic distortion of the data caused by ball impact, the moments were computed from unsmoothed coordinates until three frames before ball impact and then extrapolated for fifteen points by a linear regression line. The regression line was defined for each change. After the extrapolation, all moments were digitally smoothed by a fourth-order Butterworth filter at 12.5 Hz, and then the extrapolated regions after ball impact were removed.

RESULTS & DISCUSSION:

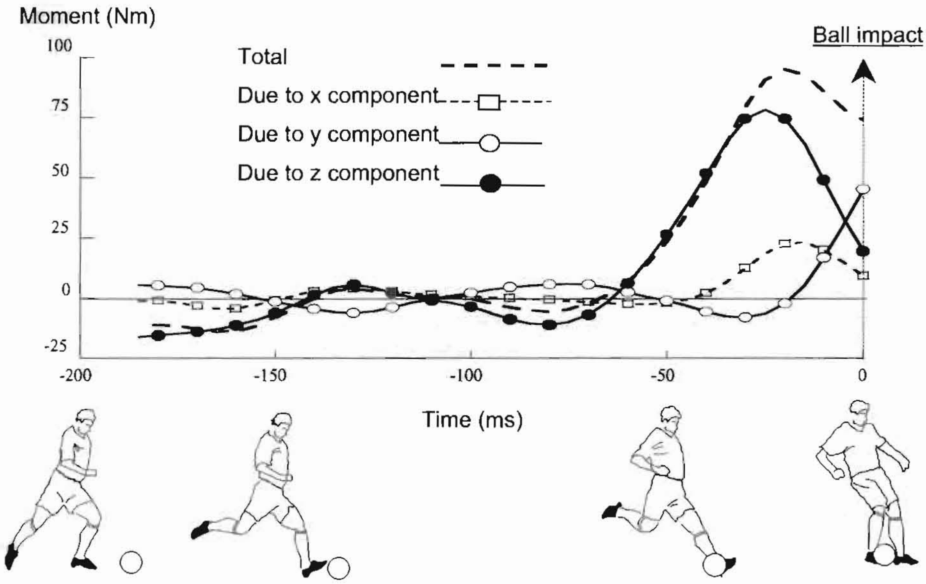

Figure 1 Typical changes of the interactive moments due to the hip linear accelerations.

In the present study, the time-series action of the interactive moment due to the hip linear motion has been clearly extracted. Typical changes of the interactive moments ($MHLA_x$, $MHLA_y$ and $MHLA_z$) due to three components (x, y and z) of the hip linear acceleration and their total ($MHLA_{tot}$) are shown in Figure 1. As shown, among the three moments, the $MHLA_z$ showed a distinctively larger magnitude than those of the other moments ($MHLA_x$ and $MHLA_y$). It can be seen that the $MHLA_z$ was the most dominant component of the $MHLA_{tot}$ and mainly serves to increase the lower leg angular velocity by generating a large positive moment during the final phase of kicking. As the hip linear motion as the source of these interactive moments, is exclusively due to the motion of the support leg (non-kicking leg), it is reasonable to assume that the effective action of the $MHLA_z$ is most likely attributed to the support leg motion immediately before ball impact.
Inoue et al., (2000) examined the effects of the hip lifting on the kicking leg swing speed using a computer simulation. They found an increase of the leg swing speed when the kinematic data of the skilled players with larger upward hip displacement was used for the calculation. Figure 2 shows the typical change of each component of the hip linear acceleration during kicking. As shown, a large upward acceleration was exhibited during the final phase of kicking. This indicates that the upward lift of the hip induced the positive action of the $MHLA_z$, thereby angularly accelerating the lower leg toward ball impact. The results of the present study seem to be consistent with the results of Inoue et al., (2000) and emphasized the importance of the upward hip lift for a faster kicking leg swing from a kinetic perspective. It can be suggested that the knee extension motion typically observed for the

support leg likely links to the upward lift of the hip, by which the effective action of the interactive moment to be induced.

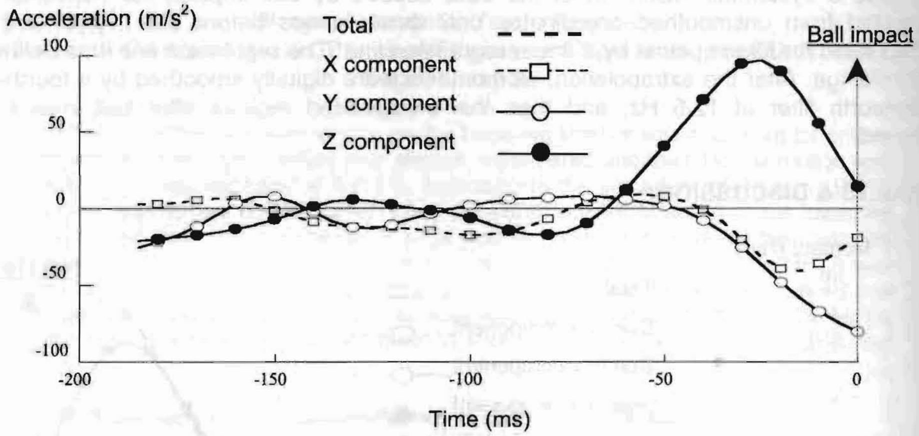

Figure 2 Typical changes of the hip linear accelerations.

CONCLUSION: In the present study, the effect of the interactive moment due to the hip linear motion on the lower leg angular motion was clearly illustrated. During the final phase of kicking, this moment mainly caused by the upward hip lift plays a substantial role to increase the lower leg angular velocity. As the vertical hip lift is exclusively served by the support leg motion, it is reasonable to assume that the effective action the moment due to the upward hip lift is most likely due to the support leg motion such as the knee extension motion during kicking.

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