A KINETIC COMPARISON OF THE INSIDE SOCCER KICK BETWEEN HIGH PERFORMANCE PLAYER AND JUNIOR PLAYERS

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Kinetic aspect of the inside soccer kick was investigated and comparison was made between those of a high performance player and junior players. One high performance player and five junior players volunteered to participate in this study. Their kicking motions were analyzed through three-dimensional cinematograpgic technique. Joints torques, generated at hip and knee joints, were computed by a three-link kinetic chain composed of thigh, shank, and foot. A marked difference was observed for the hip external rotation torque. All the junior players exhibited hip external rotation torque, and its magnitude was particularly dominant in the latter part of leg swing. Conversely, the magnitude of hip external rotation torque for the professional player was negligible. These results may help to explain differences in kicking techniques between the two levels of players.

KEY WORDS: inside kick, joint torque, soccer

INTRODUCTION: Among the various skills required in soccer, kicking is recognized as the most important and widely documented skill. Depending on the nature and intent of the kick, players select the one that is the most appropriate. In general, the inside kick is most frequently used when a shorter and precision pass and/or shot are required. According to the study that analyzed techniques used to score the goal in the last World Cup (Grant, Reilly, Williams & Borrie, 1999), the inside kick was the most common technique that selected and was used to score 16 out of 17 goals from penalty kicks.

Although there were several studies related to the soccer kick (Robertson, Zernicke, Youm and Huang, 1974; Robertson & Mosher 1985; Putnam, 1991), minimal information is available specifically for the inside kick. Recently, the angular motion required in the inside kick was compared with those required in the instep kick (Levenon & Dapena, 1998). However, the kinetic aspect of this move still is not quantified. It was supposed that, in order to hit the ball with the medial side of the foot, several complicated series of rotational joint motions would be required in this kick. Therefore, this study was designed to investigate the kinetic aspect of the inside kick and to compare the kinetic parameters between those of high performance player and junior players.

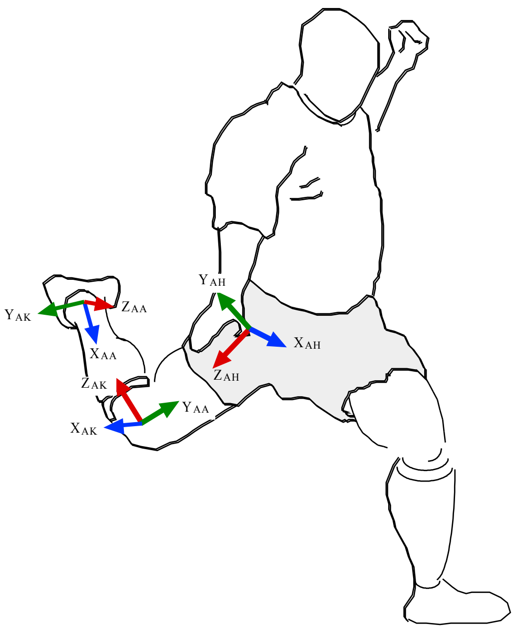

Figure 1 - Right-hand orthogonal reference frames fixed on each joint center.

METHODS: One world-class professional player (height = 174.3 cm; weight = 72.5 kg) and five high-school players (height = 174.6 ± 4.9 cm; weight = 67.6 ± 4.8 kg) volunteered to participate in this study. The professional player had participated in two World Cups (1990 and 1998) and the junior players were the members of a high school team. After a short period of warm-up, the players were instructed to perform an inside kick, with maximum effort, to the center of the 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 player and two electrically synchronized high-speed video cameras (NAC Inc., Tokyo, Japan) were used to sample the kicking motion at 200 Hz (shutter speed was 1/2000 s) from the rear and kicking leg (right) side. Of three trials, the one trial per player in which the ball contacted closest to the center of the goal was analyzed. A digitizing system (DKH Inc., Tokyo, Japan) was used to manually digitize body landmarks including: both shoulders and hips, right knee, right ankle, right heel, and right toe. The center of the ball was also digitized in its initial stationary position and in all the available frames after it left the foot. The direct linear transformation (DLT) method (Abdel-Azis & Karara, 1971) was used to obtain the 3-D coordinate of each landmark.

According to a procedure described by Feltner & Dapena (1989), the kicking leg was modeled as a three-link kinetic chain composed of the thigh, shank, and foot. For this calculation, the sum of all torques applied to each segment was set as equal to the vector product of the segment's moment inertia and angular acceleration. Mass of the shoe and its effect on the inertial property of the foot segment was assumed to be negligible.

The torque vectors applied between the leg segments were separated into orthogonal components using unit vectors included in anatomically-relevant references frames defined at hip (R_{AH}), knee (R_{AK}) and ankle (R_{AA}) joints (see Figure 1). Hip torque vector was separated into three components: adduction ($+X_{AH}$) / abduction ($-X_{AH}$), flexion ($+Y_{AH}$) / extension ($-Y_{AH}$), and external ($+Z_{AH}$) / internal rotation ($-Z_{AH}$). Knee torque vector was separated into two components: extension ($+X_{KA}$) / flexion ($-X_{KA}$) and external ($+Z_{KA}$) / internal rotation ($-Z_{KA}$). Ankle torque vector was separated into two components: plantar-flexion ($+Y_{AA}$) / dorsi-flexion ($-Y_{AA}$) and eversion ($+Z_{AA}$)/ inversion ($-Z_{AA}$).

The impact of the foot with the ball produces a sudden deceleration of the kicking leg, which cause a serious distortion of the kinetic data near the impact. To avoid such systematic errors, the time-dependent joint torque data were digitally smoothed in a forward order (toward to the impact) by a second-order Butterworth low-pass filter (Winter, 1990) at 12.5 Hz. Although this smoothing procedure followed in this study may minimized the risk of systematic errors steaming from the impact, as its reverse order of filtering to eliminate phase distortion was canceled, the data was still prone to include phase distortion.

RESULTS AND DISCUSSION: In previous research on this topic, Levenon & Dapena (1998) reported the initial ball velocity of the inside kick for intercollegiate players (22.5 ± 1.8 m/s). However, in the present study, the ball velocity of the professional player (22.0 m/s) was quite similar to the value previously reported. On the other hand, the ball velocity of the high-school players (24.3 ± 0.8 m/s) was somewhat faster than both of the values mentioned above.

As there are no studies directly comparable with the results about the kinetic parameters, an attempt was made to understand the kinetic aspect of the inside kick through a comparison between the one highly skilled professional player and the high-school players' group. Figure 2 shows the changes in joint torques for the hip adduction / abduction, flexion / extension and external / internal rotation, and knee flexion / extension during the kick in which 0 % and 100% of the time corresponding to right toe off and ball impact, respectively. The remaining torques were negligible (less than 10 Nm) and, therefore, not presented.

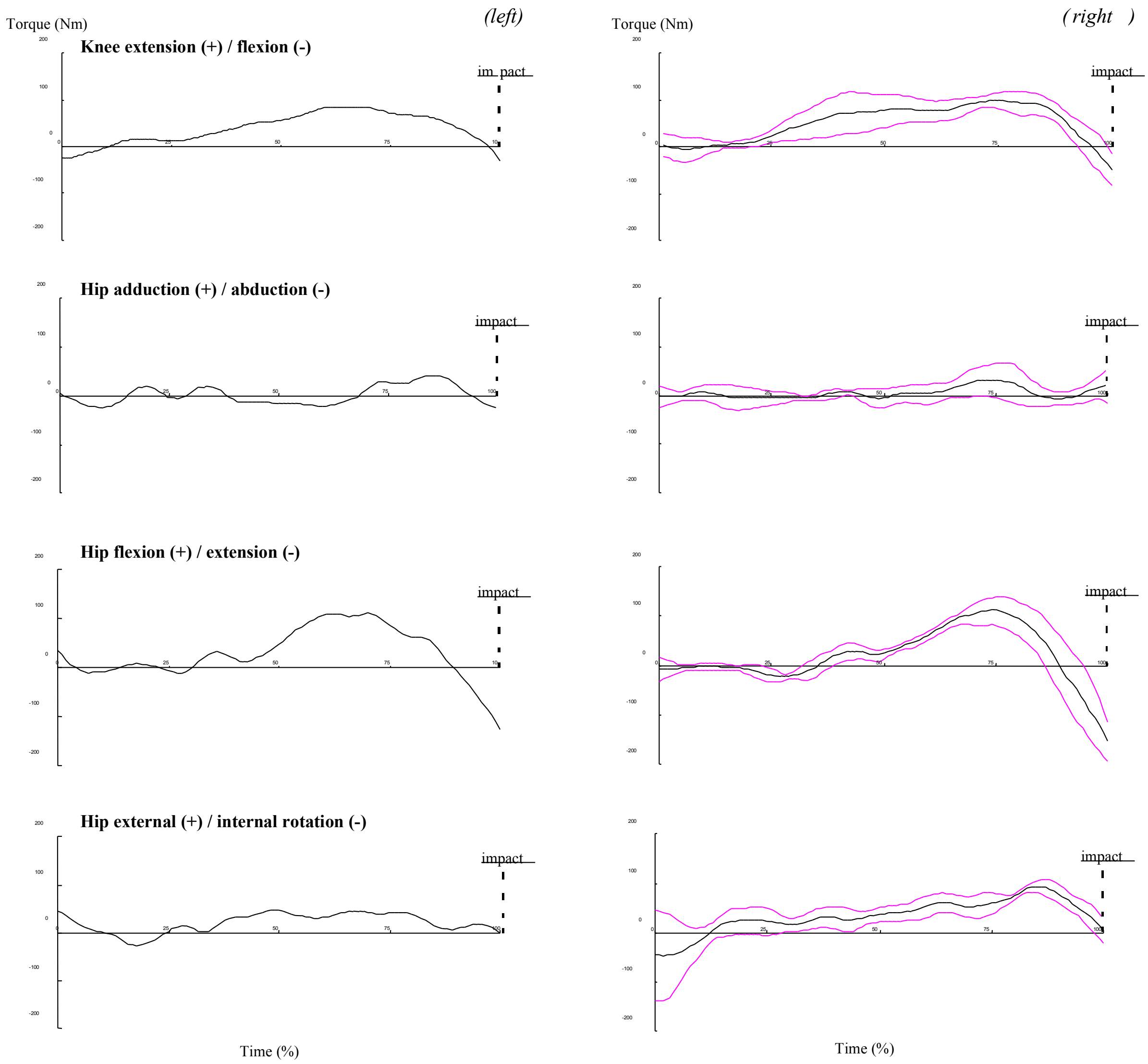

Figure 2 - Changes in joint torques at the knee and hip for ensemble average (±SD) of

the high-school players (right) and one trial of the professional players

Throughout the kicking, the general patterns of the hip flexion / extension and knee extension torques were similar between the two levels of players. However, a marked difference was observed at the latter part of the leg swing. As shown, all the junior players exhibited the hip external rotation torque and reached the peak magnitude (78.8 $\pm$ 7.8 Nm) after t = 75 %. Moreover, the peak magnitude of this torque was comparable to that of the knee extension torque (74.8 ± 9.3 Nm). Conversely, the hip external rotation torque for the professional player showed the opposite trend in which the magnitude of the hip external rotation torque rapidly decreased and was recessive.

These results partially confirm the different biomechanics underlying the kicking techniques between the two levels of players. Since the hip external rotational torque was remarkably dominant only for the high-school players, it should be suggested that the technique employed by the high-school players needs a relatively complicated series of rotational motions to hit the ball using the medial side of the foot. This finding may also help to explain differences in performance and possibility of lesion caused by over-practicing between the two levels of players.

CONCLUSION: At the latter part of the leg swing, the hip external rotation torque was quite dominant for the junior players whereas that of the high peformance players was recessive. This finding suggests the biomechanics underlying the kicking techniques is clearly different between the two levels of players in which the junior players employed a relatively complicated series of rotational motion to hit the ball with medial side of the foot.

REFERENCES:

Abdel-Azis, Y,I., & Karara, H.M. (1971). Direct linear transformation from computer coordinates into object space coordinates in close-range photogrammetry. *Proceedings ASP Symposium on Close-Range photogrammetry*, pp. 1-18.

Feltner, M.E., and J. Dapena. (1986). Dynamics of the shoulder and elbow joints of the throwing arm during a baseball pitch. *International Journal of Sports Biomechanics*, **2,** 235-259.

Grant, A.,. Reilly, T., Williams, M., & Borrie, A. (1998). Analysis of the goal scored in the 1998 world cup. *The F.A. Coaches Association Journal*, **2**,18-20.

Levanon, J., & Dapena, J. (1998). Comparison of the kinematics of the full-instep kick and pass kicks in soccer. *Med. Sci. Sports Exercise*, **30**, 917-927.

Putnam, C.A. (1991). A segment interaction analysis of proximal-to-distal sequent segment motion patterns. *Medicine and Science in. Sports and Exercise*, **23,**130-141.

Robertson, D.G.E., Zernicke, R.F., Youm, Y., & Huang, T.C. (1974). Kinetics parameters of kicking. In: *Biomechanics*, Nelson, R.C. & Morehouse, C.A. (Eds.). Baltimore: University Park, pp. 157-162.

Robertson, D.G.E, & Mosher, P.E. (1985). Work and power of the leg muscles in soccer kicking. In: *Biomechanics B*, Winter, D. A., Norman, R. W., Wells, R. P., Hays, K. C., &. Patla, A. E. (Eds.). Champaign, IL: Human Kinetics, pp. 533-538.

Winter, D.A. (1990). *Biomechanics of human movement*, 2nd ed. New York: John Wiley & Sons.

Zerincke, R.F., & Roberts, E.M. (1978). Lower extremity forces and torques during systematic variation of non-weight bearing motion. *Medicine and Science in Sports and Exercise.,* **10,** 21-26.