

KINETIC COMPARISON OF INSTEP SOCCER KICK BETWEEN PREFERRED AND NON-PREFERRED LEG IN HIGHLY SKILLED PLAYERS

Hiroyuki Nunome, Yasuo Ikegami, Tommy Apriantono*, and Shinya Sano**
Research Centre of Health, Physical Fitness and Sports,
Nagoya University, Nagoya, Japan

*Graduate School of Medicine, Nagoya University, Nagoya, Japan

**Graduate School of Human Informatics, Nagoya University, Nagoya, Japan

The kinetic differences of soccer instep kicking between the preferred and non-preferred leg were examined. The kicking motions of both legs were captured for five highly skilled players using a three-dimensional cinematographic technique at 200 Hz. The moments due to muscle force and segmental interactions were computed. Significantly greater ball velocity and shank angular velocity were achieved in the preferred leg. The preferred leg showed a significantly greater muscle moment than that of the non-preferred leg. No marked differences were found for the interactive moment between both legs. The results indicate that the highly skilled soccer players were able to produce a well coordinated inter-segmental motion not only for the preferred leg but also for the non-preferred leg. The faster leg swing observed for the preferred leg was most likely a result of the larger muscle moment.

KEY WORDS: segmental interaction, resultant joint moment, kicking.

INTRODUCTION: In the course of an actual soccer match, players are forced to kick the ball using not only their preferred foot but also their non-preferred foot. Thus, many players, coaches and scientists share a belief that mixed footedness is an advantage given the nature of the sport. Support for the advantage of a "two-footed" player has been shown by Strarosta (1988) who reported that the most successful players in high level competition will make shots on goal with either foot. Recently, Carey et al., (2001) also revealed that elite soccer players, either right-footed or left-footed, showed similar success rates for passing with the preferred and non-preferred foot.

Several studies tried to quantify the differences of the kicking motion between the preferred and non-preferred leg from a biomechanical perspective (Barfield, 1995; McLean & Tumilty, 1993; Dörge et al, 2002, Nunome et al, 2002). However, the dynamic changes of the muscle moments and motion-dependent interactive moments have not been illustrated properly for soccer instep kicking. The purpose of this study was twofold; (1) to clearly illustrate lower limb dynamics during soccer instep kicking and (2) to examine the kinetic differences between the preferred and non-preferred leg.

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. As each participant preferred to kick the ball using the right leg, the right leg was defined as the preferred leg. After an adequate period of warm-up, the players were instructed to perform maximal instep kicks, to a target located at the center of goal a distance of 11 m ahead. All participants performed at least five attempts with each leg so that two shots could be selected with both a good foot-to-ball impact and adequate center of targeting. Two electrically synchronized video cameras were used to capture the motion at 200 Hz (exposure time was 1/2000 s). A digitizing system was used to manually digitize body landmarks including: right and left shoulders, hips, knees, ankles, heels and toes. 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.

The resultant joint moment (muscle moment), motion-dependent interactive moment due to the joint reaction force (interactive moment) and angular velocities (thigh and shank) were computed from a two-link kinetic chain composed of the thigh and shank. 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. To resemble the final change of the data, the final eight to twelve data points were fitted to the linear regression line. For angular velocities, a quadric regression line was fitted to the unsmoothed data in the same manner. After these extrapolations, all parameters were digitally smoothed by a fourth-order Butterworth filter at 12.5 Hz, and then the extrapolated regions after ball impact were removed.

RESULTS: All participants consistently produced a faster ball velocity with the preferred leg (32.1 + 1.6 m/s) than that of the non-preferred leg (27.1 + 1.6 m/s). The average ball velocity was significantly different between the right and left legs.

Table 1 Selected kinetic and kinematic variables.

	Preferred Mean (SD)	Non-preferred Mean (SD)
Moments (Nm)		
Max. muscle moment	130 (25)	93 (20) *
Max. interactive moment	66 (39)	33 (16)
Angular velocity (rad/s)		
Max. shank angular velocity	38.7 (3.6)	29.2 (2.4) *

* Indicates a significant difference ($P < 0.05$)

The average (+ SD) changes in muscle moment and interactive moment are shown in Figure 1. The general moment patterns were similar in each leg. The muscle moment reached its peak magnitude at the middle part of kicking and rapidly decreased to a small negative value immediately before ball impact. A significant difference in the magnitude of the muscle moment between the legs was observed in the middle part of kicking. In contrast to the changing pattern of the muscle moment, the interactive moment showed a negative value until the latter part of kicking and then rapidly increased to a positive value immediately before ball impact. Table 1 summarizes the peak magnitudes of selected variables. Significant differences were found for the muscle moment and shank angular velocity whereas no substantial differences were found for the interactive moment.

DISCUSSION: Dörge et al., (2002) conducted a similar biomechanical comparison between the preferred and non-preferred leg. They found a faster leg swing of the preferred leg attributed to a greater amount of work done by the interactive moment. From this result, they concluded that the preferred leg achieved a better inter-segmental motion pattern than that of the non-preferred leg. In contrast, the kinetic aspects of the present study indicated that the faster leg swing of the preferred leg was not characterized by a better segmental interaction (the interactive moment) but by greater muscle efforts (the muscle moment) during kicking. Although the ball velocity and shank angular velocity of the non-preferred leg were significantly slower than those of the preferred leg, these values are even higher than those of the preferred leg reported by Dörge et al., (2002) (ball velocity = 24.7 m/s; shank angular velocity = 28.1 rad/s). One possible explanation for this disagreement between the two studies is that the highly skilled players in the present study achieved a well coordinated kicking motion not only for the preferred leg but also for the non-preferred leg. For these players, the ability to explosively generate greater muscle moment would produce the difference in leg swing velocity between the preferred and non-preferred leg.

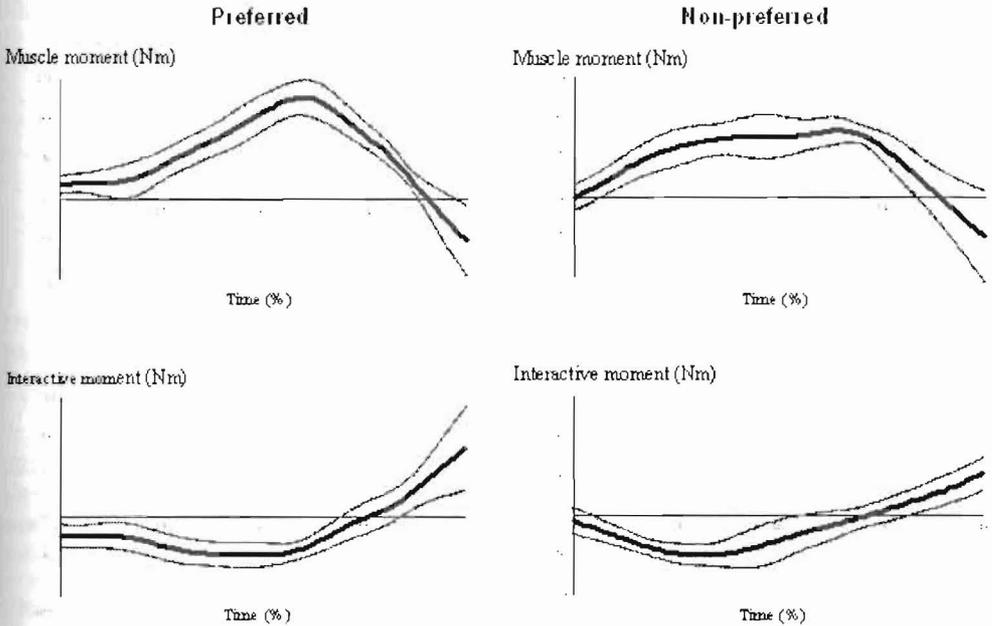


Figure 1: Ensemble changes in muscle moment (top) and interactive moment (bottom) at the knee of the preferred (left column) and non-preferred (right column) leg. Time from the moment of right toe off to ball impact was normalized to 100%.

CONCLUSION: In the present study, the action of the resultant joint moment and motion-dependent interactive moment during soccer instep kicking were clearly illustrated. The faster leg swing of the preferred leg was not characterized by a better inter-segmental pattern but by a greater muscle moment than the non-preferred leg.

REFERENCES:

- Barfield, W. R. (1995). Effects of selected kinematic and kinetic variables on instep kicking with dominant and nondominant limbs. *Journal of Human Movement Study*, 29, 251-272, 1995.
- Carey, D., Smith, G., Smith, D. T., Shepherd, J. W., Skriver, J., Ord, L., & Rutland, A. (2001). Footedness in world soccer: an analysis of France '98. *Journal of Sports Sciences*, 19, 855-864.
- Dörge, H. C., Andersen, T. B., Sørensen, H. & Simonsen, E. B. (2002). Biomechanical differences in soccer kicking with the preferred and the non-preferred leg. *Journal of Sports Sciences*, 20, 293-299.
- McLean, B. D. & Tumilty, D. (1993). Left-right asymmetry in two types of soccer kick. *British Journal of Sports Medicine*, 27, 260-262.
- Nunome, H., Asai, T., Ikegami, Y. & Sakurai, S. (2002). Three-dimensional kinetic analysis of side-foot and instep soccer kicks. *Medicine and Science in Sports Exercise*, 34, 2028-2036.
- Starosta (1988). Symmetry and asymmetry in shooting demonstrated by elite soccer players. In T. Reilly, J. Clarys and A. Stibbe (Eds), *Science & Soccer* (pp, 346-355). London: E & FN Spon.