BIOMECHANICAL RELATIONSHIP BETWEEN THE GOALKEEPER AND KICKER MOTIONS IN SOCCER

Naoki Numazu[1] and Norihisa Fujii[1]

Faculty of Health and Sport Sciences, University of Tsukuba, Tsukuba, Japan[1]

The purposes of the study were; (1) to identify the relationship between kicking motion of kickers and diving motions of goal keepers (GKs), and (2) to investigate the knowledge which can anticipate the moving direction after the preparatory motion from the kicking motion. Fourteen collegiate male GKs and 11 collegiate outfield players participated in this study. The mimic real shooting situation was captured using a motion capture system. The primary findings were: regardless of the shot direction (rightward and leftward), the motion timing of preparatory motion is similar. The GKs started jumping at the same time as grounding of kicker's support leg or immediately after contacting the ball. In addition, it is determined that the GKs pre-judged the shot direction while they were jumping as they had watched the kickers' movement in the approach phase.

KEYWORDS: shot direction, preparatory motion, dribbling angle

INTRODUCTION: In soccer games, Numazu, Fujii, Nakayama, and Koido (2017) reported that the collegiate GKs often use a counter movement as a preparatory motion when saving the ball. This preparatory motion is used in many other sports such as tennis. Uzu, Shinya & Oda (2009) reported that the preparatory motion in tennis increases the velocity of a lateral stepping movement in the "know when not where" situation. Uzu et al. (2009) also reported that this benefit depends on the timing of the landing from the preparatory motion. In many sports, players watched the opposing players' motion before they reacted. Aviles, Benguigui, Beaudoin & Godart (2012) reported that an elite tennis player always jumps as a receiver before the server hit the ball and landed shortly after the server makes ball contact with the racquet. Therefore we hypothesize that the GKs in soccer would also utilize a preparatory motion so as to approach to the shot exactly before the kickers have kicked the ball and to land shortly after the kicker makes ball contact. In addition, if it can be anticipated from the kicking motion the required moving direction, this knowledge might be useful for GKs. The purposes of this study were 1) to identify the relationship of the motion timing between kicking motion of the shooter and diving motions of the GK and 2) to investigate the knowledge which can anticipate the moving direction after the preparatory motion from the kicking motion.

METHODS: Fourteen male collegiate GKs (1.78 ± 0.03 m, 75.1 ± 8.6 kg) and eleven male collegiate outfield players (1.73 ± 0.05 m, 69.7 ± 5.4 kg) were recruited for the study. Three-dimensional coordinate data of the kicker and the GK motions were measured with two motion capture systems (VICON-MX, Vicon Motion Systems, 16 cameras were used for the GKs, 8 cameras were used for the kickers, 250 Hz). These systems were synchronized by an analog signal (1000 Hz). Ground reaction forces of the GKs were measured using two force platforms (9287B , 9287C, Kistler, 1000Hz). We conducted experiments in a laboratory under the mimic real shooting situation as per Numazu, Fujii, Nakayama, and Koido (2016). Figure 1 shows a schematic view of kicking direction. We instructed the required shot area only to the kicker using a schematic before each trial. Shot areas were allocated across 12 locations (right and left, near and far, and upper, middle, and lower) as per Matsukura and Asai (2013). Shot distances from the GK were set for near and far (near is 1.8m away from the GK, and far is 1.8 to 3.6 m away from the GK). Shot heights were set for lower (from 0 to 0.8m high), middle (0.8 to 1.6m high), and upper (from 1.6 to 2.4m high). The kicker stood 16.5 m away from the GK. Kickers were instructed to perform instep-kicking to the shot area as accurately as possible with forward 2m dribbling. The shot area (x12 locations) was instructed randomly. The GKs were instructed to stand on two force platforms with each foot on a different platform in a comfortable position and to dive with preparatory motion toward the shot. For further analysis, we selected 290 trials (rightward: 191 trials; leftward: 99 trials) which the GKs were required to dive toward in the shot areas. We defined the leg corresponding to diving direction

as the ball-side (BS) leg; the other side leg as contralateral side (CS) leg (Matsukura & Asai, 2013). The ball center was estimated from reflective markers on the ball using the least-square method. Coordinate values were smoothed using a Butterworth low-pass filter with optimal cut-off frequencies determined by the residual error method (Winter, 2004).

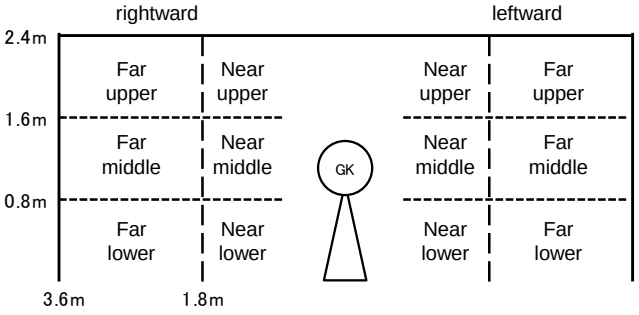


Figure 1: Shot area breakdown

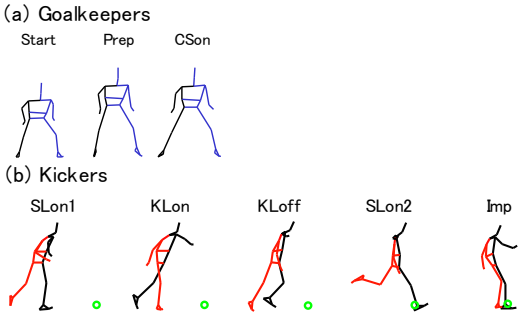
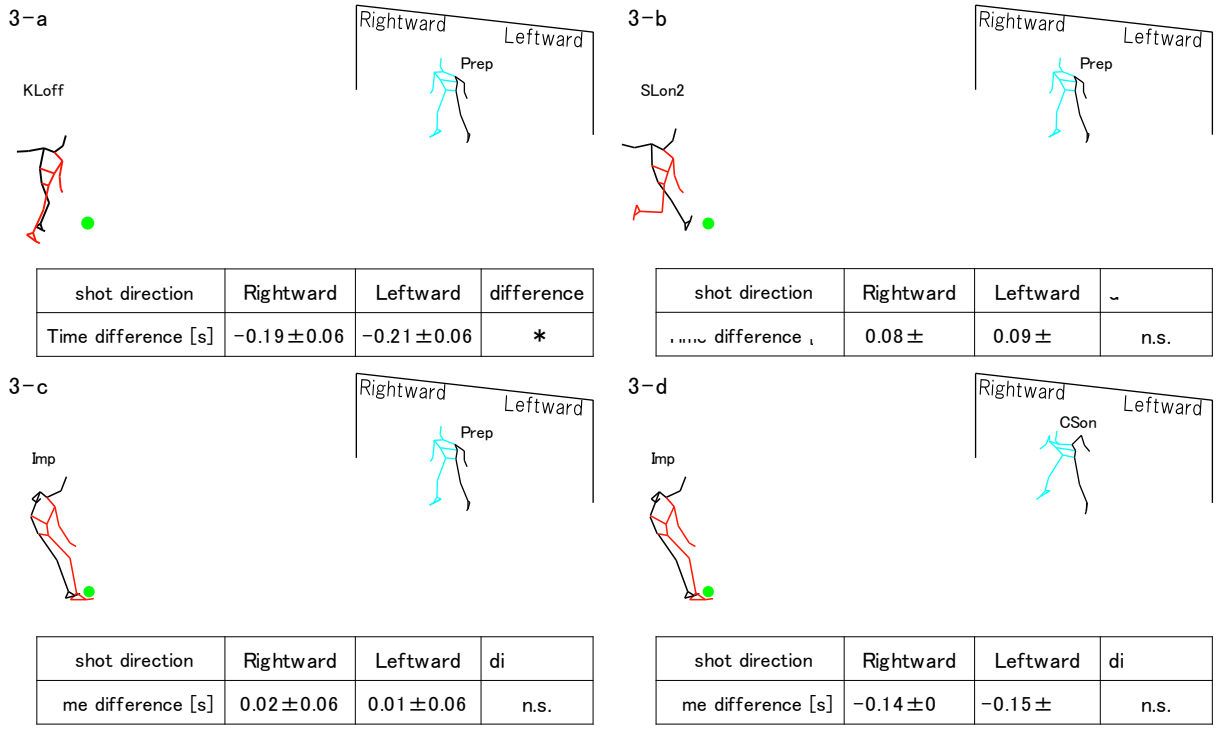


Figure 2: Analysis events

Figure 2(a) shows analysis events for the GKs. Prep was defined as the timing of the preparatory motion when the first foot left the ground. CSon was defined as the timing of the landing of the CS leg after preparatory motion. For the kickers' motion, we divided the approaching and kicking motions into five events (Figure 2(b)).The relationship of the motion timing between kicking and diving motions were calculated by subtracting each GKs' motion event (Prep or CSoff) from each kickers' motion event (KLoff, SLon2 or Imp). Therefore, the positive values mean that the GKs' motion event occurred before the kickers' motion event. The center of gravity (CG) coordinates of the kickers were estimated from the body segment parameter method of Ae (1996). Dribbling direction angle with which the kicker dribbled the ball at SLon1, was defined as the angle between the vector from the kickers' CG to the ball center and the global anterior-posterior axis. An independent t-test was used to evaluate differences between shot directions (rightward and leftward) with significance level of $\alpha = 0.05$. In addition, effect size was calculated for differences between shot directions according to Cohen (1988) (d=small > 0.2, medium>0.5 and large >0.8).

RESULTS: Table 3a shows the time difference between KLoff and Prep. Regardless of the shot direction, the timings of Prep were seen after about 0.2 s of KLoff. But, the GK in the rightward trials started to jump earlier than the leftward trials (rightward: -0.19±0.06 s; leftward: -0.21±0.06 s, d=0.28, p< 0.05). Table 3b shows the time difference between SLon2 and Prep. Regardless of the shot direction, the timings of Prep were observed at almost the same time as SLon2 (rightward: -0.08±0.07 s; leftward: -0.09±0.06 s, d=0.18, n.s.). Table 3c shows the time difference between Imp and Prep. Regardless of the shot direction, the timings Prep were seen at the almost same time as Imp (rightward: 0.02±0.06 s; leftward: 0.01±0.06 s, d=0.23, n.s.). Table 3-d shows the time difference between Imp and CSon. Regardless of the shot direction, the timings of CSon were seen after about 0.15 s of Imp (rightward: -0.14±0.05 s; leftward: -0.15±0.04 s, d=0.26, n.s.). Table 4 shows the moving distances of the kickers' CG along the lateral axis from SLon1 to SLon2. The kickers in leftward trials moved more distance than rightward trials (rightward: 0.70±0.16 m; leftward: 0.80±0.21m, d=0.58, p< 0.05). Table 5 shows the dribbling angles in SLon1. The kickers in leftward trials dribbled more widely than rightward trials (rightward: -34.8±5.1 deg; leftward: -40.3±6.9 deg, d=0.95, p< 0.05).



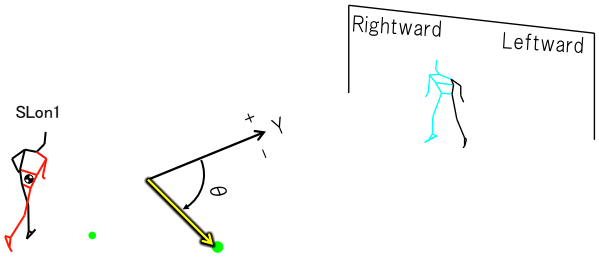
shot direction	Rightward	Leftward	difference
Time difference [s]	−0.19±0.06	−0.21±0.06	*

shot direction	Rightward	Leftward	
difference	0.08±	0.09±	n.s.

shot direction	Rightward	Leftward	di
me difference [s]	0.02±0.06	0.01±0.06	n.s.

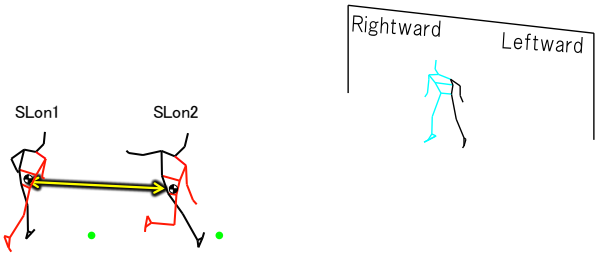
shot direction	Rightward	Leftward	di
me difference [s]	−0.14±0	−0.15±	n.s.

Table 3 Time differences between the GK's motion and the kickers' motion.



shot direction	Rightward	Leftward	difference
Angle [deg]	34.8±	40.3±	*

Table 4 Dribbling direction angle (positive: Rightward)



shot direction	Rightward	Leftward	difference
distance [m]	±	±	*

Table 5 Moving distances

DISCUSSION: In the results of Table 3, effect sizes are small (d=0.18-0.28). The GKs started jumping at almost the same time of SLon2 and immediately after Imp. These results are well in line with our hypothesis. In tennis, Uzu et al. (2009) reported that tennis players should land about 0.18 s after the visual cue to produce a quick and reliable lateral step for the correct movement. In the previous study, the participants watched the LED signals which indicated the moving direction. In contrast, the participants in the present study could watch the kickers' movement. Therefore, it was thought that the GKs could prepare to approach the shot quickly and make contact with their foot, are similar with the previous study (Aviles, Benguigui, Beaudoin & Godart, 2012). It is assumed that GKs could also judge the direction that they should move after landing because they started to approach the ball immediately after the preparatory landing motion occurred.

We also investigated that the kickers increased their moving distance and dribbled more widely when they kicked to the left. It appears to the GK that the kicker moves more to the left when the intended shot is leftward. Knowledge about the kickers and their preferences might be helpful for the GKs. In the present study, however, the kickers were not instructed so as not to reveal the shot direction to the GKs. Therefore, the kickers might adjust easily to kick to the shot direction instructed before the trial.

CONCLUSIONS: Regardless of the shot direction, the timing of preparatory motion is similar. GKs commence jumping at the same time as the kickers ground their support leg, or immediately after hitting the ball. In addition, it is thought that the GKs have already judged the direction quickly while they were jumping because they had watched the kickers' movement in approaching phase. As such, GKs should gaze at the kicking motion of the opponent and at the approaching motion in order to judge their moving direction.

REFERENCES:

Ae, M. (1996): Body segment inertia parameters for Japanese children and athletes. *Japanese Journal of Sports Sciences*, 15, 155-162.

Aviles, C., Benguigui, N., Beaudoin, E., & Godart, F. (2002): Developing early perception and getting ready for action on the return of serve. *ITF Coaching and Sport Science Review*, 28, 6-8.

Cohen, J. (1988): Statistical power analysis for the behavioral sciences. New York: *Academic Press*.

Numazu, N., Fujii, N., Nakayama, M., & Koido, M. (2017): Game performance analysis in the university male soccer goalkeepers. *The Japan Journal of Coaching Studies*. 31(1), 43-52.

Matsukura, K. & Asai, T. (2013): Characteristics of force exerted by soccer goalkeepers during diving motion (in Japanese). *Japan Journal of Physical Education, Health and Sport Sciences*. 58, 277-296.

Uzu, R., Shinya, M., & Oda, S. (2009): A split-step shortens the time to perform a choice reaction step-and-reach movement in a simulated tennis task. *Journal of Sports Sciences*. 27(12), 1233-1240.

Winter, D. A. (2004): *Biomechanics and motor control of human movement* (third edition, pp. 37-38). New York: John Wiley & Sons.