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BALL DISTRIBUTION USING THE INSTEP KICK IN COLLEGIATE SOCCER PLAYERS

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The present study investigates the characteristics of the distribution of the soccer ball during the instep kick to clarify the reproducibility of the ball distribution. Six male collegiate soccer players kicked a soccer ball towards a goal 11 m away (5 sets of 10 trials). Ball distribution was then analyzed using a high-speed camera. In relation to ball velocity, no differences were seen between sets in the distribution distance from the center of the goal (in either the x-axis or the y-axis direction) among all subjects. High reproducibility was observed for all items. Furthermore, no differences were observed between sets in the slopes and intercepts of the regression equations for the ball distribution. These values also showed high reproducibility. An elliptical shape from the lower left to the upper right was revealed after analysis of ball distribution for the instep kick.

KEY WORDS: repeatability, accuracy, kick motion

INTRODUCTION: A number of previous studies have focused on various aspects of soccer kicks. On the other hand, previous studies have only focused on the operation and speed of kicking the ball; no studies have focused on the accuracy of the kicked ball. The distribution of the ball is used as one of the metrics that represent the accuracy of the sport ball (Katsumata et al., 2004; Motoyasu et al., 2011; Jonathan et al., 2007). However, ball distribution related to the kicks of soccer players has not been reported. The purpose of this study was both to examine the distribution of the soccer ball in college soccer players with more than 10 years of competitive experience using the instep kick and to clarify the reproducibility of the distribution.

METHODS

SUBJECTS: Six male members of a university soccer team (age: 23.3 ± 1.8 cm; soccer career: 15.3 ± 2.4 years; height: 171.7 ± 4.4 cm; mass: 63.7 ± 6.5 kg) voluntarily participated in this study. The dominant leg for all of the subjects was the right leg. The subjects provided written informed consent after being informed of the study purpose and associated risks.

EXPERIMENTAL DESIGN: After stretching and warming up, the subjects were allowed to kick the ball toward the goal (3.0 × 2.0 m) that was placed 11 m away using an instep kick. Subjects were instructed to kick the ball with maximum effort toward a mark in the center of the goal. Each set consisted of 10 kicks, and each subject completed a total of five sets. The subjects were allowed rest for 10 minutes so that fatigue would not affect the results. No information on ball speed was shared with the subjects during the kicks. A regulation soccer ball (JFA approved, ball pressure: 0.80–0.85 kg/cm^2, Mikasa Corporation) was used.

MEASUREMENTS: Ball velocity was measured using a radar gun (Mizuno Corporation) positioned behind the goal. The distribution of the ball was measured using two high-speed cameras (EX-F1, Casio Corporation) with a sampling rate of 300 Hz and shutter speed of 2000 Hz. One camera was positioned behind the goal and the other camera was positioned at the side of the goal. The two cameras (DHK Corporation) were synchronized using a synchronization indicator. The time frame in which the ball passed through the goal line was calculated from the image captured by the camera positioned at the side of the goal. The center coordinates of the ball were calculated from the image captured by the camera positioned behind the goal using image analysis software (Dartfish Software, Dartfish Corporation). The distance from the center of the goal (both the x-axis and y-axis direction)

was calculated using the absolute value, and the average value was calculated for each set. The y-axis direction was defined as having a positive value when the ball reached the goal above the center, and the x-axis direction was defined as having a positive value when the ball reached the goal to the right of the center. The ball distribution was divided into four (Figure 1).

RESULTS: Table 1 shows ball velocity for each subject. No significant difference was observed in ball velocity between the sets for each subject. Moreover, no significant difference was evident in average ball velocity between the sets for all subjects.
Figure 1 shows the ball distribution in each set for each subject. For all subjects, a ball distribution with an elliptical shape from the lower left to the upper right was observed. This represents one of the characteristics of ball distribution during the instep kick. Table 1 shows the distance from the center of the goal (in the x-axis and y-axis directions) for each subject. No significant difference was observed between sets for each subject. Moreover, no significant difference was observed between sets in the average value of the distances for all subjects.
For ball velocity and distance from the center of the goal in the x-axis and y-axis directions for each subject, no significant differences were observed between the sets. The data of all subjects were integrated for each set. No significant differences were observed in the slopes and intercepts of the regression equations for the ball distribution between the sets (Set 1: $y = 0.25x - 0.27$; Set 2: $y = 0.35x - 0.09$; Set 3: $y = 0.47x - 0.17$; Set 4: $y = 0.46x - 0.14$; and Set 5: $y = 0.27x - 0.12$).
No significant differences were found in ball distribution between sets. Therefore, the data from all of the attempts of all subjects were combined to clarify the characteristics of ball distribution for soccer players. The distribution ratio of each indicator ball was as follows: category1, 27%; category 2, 20%; category 3, 39%; and category 4, 14%. The distance from the center of the goal was significantly greater in the x-axis direction than in the y-axis direction ($p < 0.001$).

DISCUSSION: The present study showed that ball velocity and distance from the center of the goal in the x-axis and y-axis direction were not significantly different between sets, and that ball distribution tended to be from the lower left to the upper right in an elliptical shape.
The average velocity of the soccer ball in this study was 98.8 km/h, which was within the range of the average ball velocity (87–103 km/h) measured in previous studies when college soccer players kicked with maximum effort (Apriantono et al., 2006; Gongbing, 2009). Each subject in the present study was thus thought to have performed with maximum effort. In addition, it has been reported that swing speed, and consequently ball velocity, decreases with fatigue (Apriantono et al., 2006). However, because no significant differences were evident between the average ball velocities in all subjects in the present study, fatigue most likely had no effect. No significant differences were observed in the slopes and intercepts of the regression equations for ball distribution, which indicates high reproducibility. Based on the fact that no difference was seen in the distance from goal center, no difference is apparent between each set also in the distribution of the ball, even if the invention the solve the number 10, it is possible to reflect the characteristics of the distribution ball instep kick of a football player it has been suggested. Considering ball distribution after combing all of the data, it is a rate of the ball attainment position of each classification were as follows: category 1, 27%; category 2, 20%; category 3, 39%; and category 4, 14%. Classifying the ball distribution into four categories revealed a distribution with an elliptical shape from the lower left to the upper right. In a previous study examining the accuracy of the in-front kick, the ball velocity, the amount of rotation, and various parameters such as the angle outleap interact, have been reported to affect the distribution of the ball attainment position (Shimizu and Maeda, 2012). Various parameters that affect the kicking motion can be inferred. Examination based on ball distribution and kick operation is considered necessary. The distance from the center of the

goal was significantly greater in the x-axis direction than in the y-axis direction ($p < 0.001$). The presence or absence of competitive experience, regardless of years of experience handling a basketball, results in a greater deviation in the position of a basketball in the longitudinal direction after a free throw, compared to that in the left-right direction (Motoyasu, 2011). Therefore, it is possible that the difference in the distance from the center in the x-axis direction and y-axis direction when kicking a soccer ball toward the goal shows the characteristics of the distribution of soccer players. In other ball games, the variation of the ball distribution has been shown to increase with increasing ball velocity (Cauraugh et al., 1990; Jonathan et al., 2007; Katsumata et al., 2004; Lidor et al., 2007). Therefore, it is possible that ball velocity affects distribution. However, this study did not take ball velocity into consideration, and thus ball distribution at different ball velocities should be considered in future studies.

CONCLUSIONS: The present study investigated the characteristics of soccer ball distribution using the instep kick and clarified the reproducibility. The following conclusion can be drawn from the results of the study.

1) No differences in the distance from the center of the goal were observed in either the x-axis or y-axis direction, as well as in ball velocity, between the sets in all subjects. This indicates the high reproducibility of the study.
2) The instep kick showed a ball distribution with an elliptical shape from the lower left to the upper right.
3) No differences in the slopes and intercepts of the regression equations were seen between sets, even in the ball distribution. This also indicates the high reproducibility of the results.
4) In the ball distribution for all trials of all subjects, the distance from the center of the goal was significantly greater in the x-axis direction than in the y-axis direction.

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Table 1:
Ball velocity and distance from the center of the goal for each subject

	Set 1	Set 2	Set 3	Set 4	Set 5
Ball velocity					
Subj. A	103.3±6.6	104.7±7.3	104.5±5.6	106.2±7.6	105.9±3.6
Subj. B	95.5±2.6	97.2±3.5	99.4±3.1	98.6±4.5	97.3±3.8
Subj. C	101.2±3.0	101.2±2.4	101.6±3.1	98.9±4.9	98.2±2.3
Subj. D	100.7±5.2	101.3±3.8	99.7±2.3	98.9±2.6	98.5±3.7
Subj. E	95.7±3.0	96.3±3.8	98.3±3.0	96.7±4.2	97.3±1.9
Subj. F	92.8±1.8	92.6±4.9	93.5±1.3	94.1±2.4	95.3±1.8
All	98.2±5.4	98.9±5.9	99.5±4.6	98.9±5.8	98.8±4.4
Distance from goal center (x-axis)					
Subj. A	0.52±0.31	0.41±0.36	0.51±0.41	0.50±0.44	0.37±0.25
Subj. B	0.61±0.40	0.70±0.36	0.57±0.42	0.61±0.35	0.72±0.46
Subj. C	0.46±0.42	0.52±0.23	0.62±0.39	0.84±0.20	0.63±0.41
Subj. D	0.65±0.36	0.69±0.43	0.56±0.49	0.71±0.42	0.73±0.38
Subj. E	0.43±0.39	0.54±0.40	0.62±0.34	0.62±0.30	0.54±0.42
Subj. F	0.79±0.44	0.54±0.32	0.44±0.25	0.66±0.44	0.61±0.45
All	0.58±0.41	0.57±0.37	0.55±0.40	0.66±0.39	0.60±0.42
Distance from goal center (y-axis)					
Subj. A	0.35±0.25	0.50±0.30	0.45±0.26	0.42±0.29	0.60±0.25
Subj. B	0.57±0.32	0.25±0.13	0.45±0.26	0.45±0.20	0.37±0.20
Subj. C	0.54±0.34	0.63±0.26	0.53±0.24	0.35±0.24	0.48±0.28
Subj. D	0.53±0.35	0.48±0.30	0.62±0.28	0.55±0.20	0.40±0.27
Subj. E	0.47±0.27	0.37±0.29	0.53±0.31	0.61±0.32	0.49±0.30
Subj. F	0.50±0.20	0.49±0.29	0.30±0.22	0.40±0.30	0.37±0.23
All	0.49±0.30	0.45±0.30	0.48±0.29	0.46±0.28	0.45±0.27

Unit: Ball velocity (km/h), Distance from goal center (m)

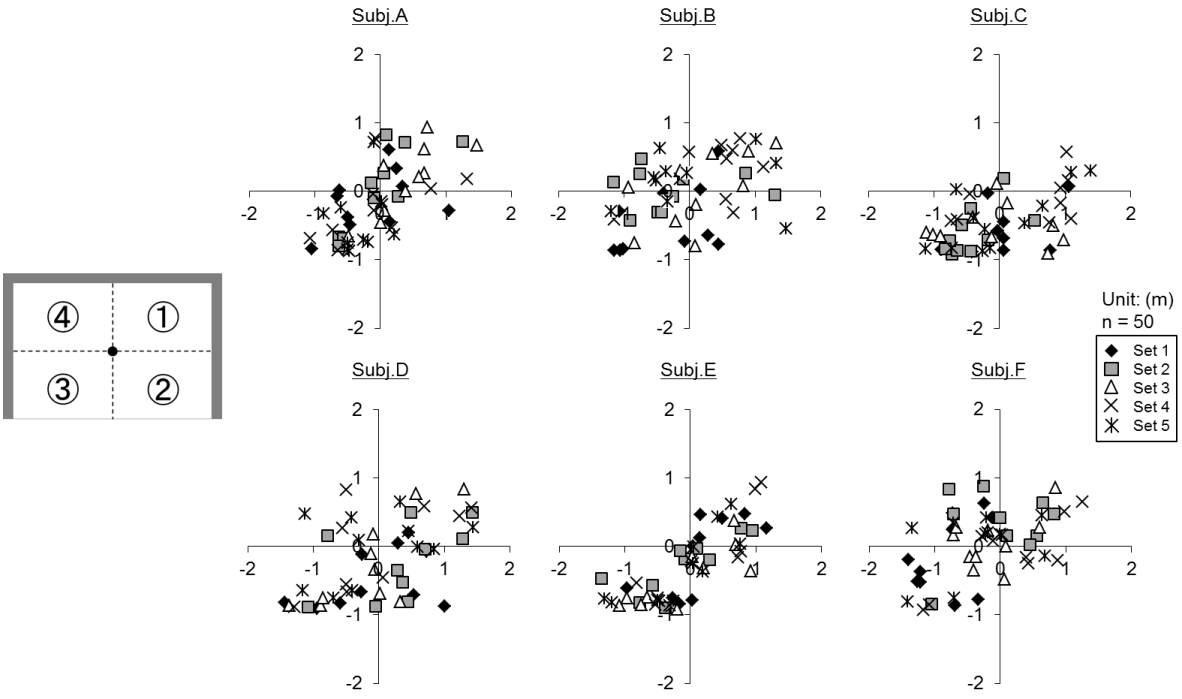

Figure 1: Ball distribution for each subject