# BALL IMPACT CHARACTERISTICS OF KNUCKLE BALL KICKING IN SOCCER

[1] Hironari Shinkai, [1] Hiroyuki Nunome, [1, 2] Harutomo Suzuki, [3] Hiroshi Suito and [1] Yasuo Ikegami
[1]Research Centre of Health, Physical Fitness and Sports, Nagoya University, Japan, [2]Nagoya Grampus Eight, Japan,
[3]Faculty of Psychological and Physical Science, Aichi Gakuin Universiry, Japan; email: shinkai@nagoya-u.jp

## INTRODUCTION

Recently, knuckle ball kicking with non or low ball rotation has attracted worldwide attention in soccer. To date, there are some studies that have focused on the irregular flying trajectory and aerodynamic characteristics of the knuckle ball [1,2]. However, no study has attempted to reveal how to kick the ball for success of knuckle ball kicking.

The purpose of this study was to describe the ball impact characteristics of knuckle ball kicking on a skilled kicker through a comparison of that of instep and side-foot kicking.

## METHODS

A Japanese professional footballer (age = 21 years, height = 182 cm, body mass = 76.4 kg), who is member of national squad and is well known as good kicker of knuckle ball, participated in this study. He was instructed to perform 10 knuckle ball kicks toward the soccer goal 25 m ahead.

Two normal rate (60 Hz) video cameras were set up at the side and backward to record the ball trajectory. In addition, two electrically synchronized ultra-high-speed cameras (FASTCAM-512 PCI, Photron Ltd.) were used to capture the lower leg, foot, and ball motion during ball impact phase at 2000 Hz. From these images, number of revolutions of the ball, 3-D angular displacement of the kicking foot during ball contact (plantar/dorsal flexion, adduction/abduction, inversion/eversion), and foot contact point with the ball were obtained. For comparison with knuckle ball kicking, same analysis was done for his instep and side-foot kicking.

## RESULTS AND DISCUSSION

A successful shot (trial A: launch angle = 16.2 deg, ball velocity = 30.6 m/s), which has remarkable change of the ball trajectory and hit the goal, was obtained. From the comparison with another similar trial (trial B: launch angle = 15.3 deg, ball velocity = 30.6 m/s), it seems that the ball trajectory of trial A irregularly changed downward (Figure 1). The number of ball revolutions of trial A and B were 0.8 rev/s and 1.4 rev/s, respectively. Judging from the above results, trial A was selected for subsequent analysis.

For instep kicking, the kicking foot was forced into plantar flexion, abduction, and eversion during ball contact (Figure 2). It has been reported that the foot received nearly 3000 N of the ball reaction force in instep kicking of skilled adult player [3]. It can be assumed that the magnitude of this force was so large that the muscles around the ankle can not afford to control the ankle motion. Nevertheless, the foot angular

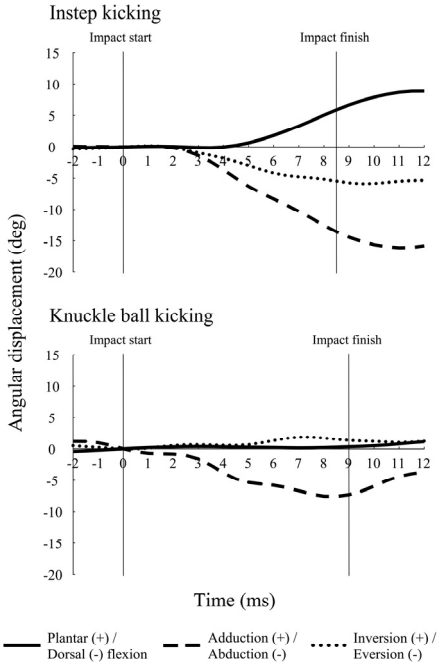


**Figure 2**: 3-D angular displacement of the foot during ball contact in instep (top) and knuckle ball (bottom) kicking.

displacements of knuckle ball kicking were restricted compared to these of instep kicking (Figure 2). In the case of knuckle ball kicking, the player impacted the ball at the medial and proximal part of the foot which was hybrid position between instep and side-foot kicking. In this situation, the ball reaction force vector would act near the foot centre of gravity and would pass from medial side to lateral side of the foot. This action may allow the player to restrict the passive foot motions during ball impact. Because the passive foot motions cause an increased rotation of the ball (gear effect), it was considered that such unique impact was effective in launching the ball with non or low rotation.

## CONCLUSIONS

The ball impact of the knuckle ball kicking performed by a skilled kicker was reasonable to minimize the ball rotation, i.e., to make a success of the knuckle ball kicking.

## REFERENCES

1. Asai T, et al., *Sports Engin*. **10**: 101-109, 2007.
2. Asai T, et al., *Science and Football VI*, Routledge, New York, 49-64, 2008.
3. Shinkai H, et al., *Med Sci Sports Exerc.* **41**: 889-897, 2009.

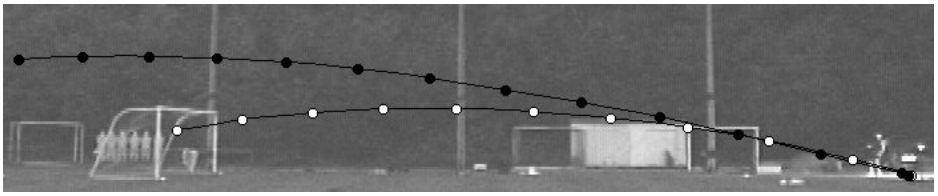

**Figure 1**: Flying trajectories of knuckle ball kicking (○: trial A, ●: trial B).