RELATIONSHIP BETWEEN ACCELERATION OF THE FOOT AND LOWER-LEG MOVEMENT IN SOCCER BALL TRAPPING

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The purpose of this study was to extract motion characteristics from the changes in foot acceleration, ball velocity after trapping, and lower-limb joint angles with regard to inside trapping of the ball in soccer. Thirteen experienced male collegiate soccer players were asked to perform inside trapping of the ball 10 consecutive times in two different tasks. Acceleration of the foot and bodily movements in trapping were recorded using accelerometers and video cameras. There was a significant correlation between ball velocity after trapping and external rotation of both the hip and knee in the first task (hip, $r=-0.62$; knee, $r=-0.65$; $p<0.05$ for both coefficients). In the second task, there was a significant correlation between the ball velocity after trapping and external rotation of the hip ($r=-0.66$; $p<0.05$).

KEY WORDS: soccer, inside trapping, foot acceleration, lower-leg joint angles.

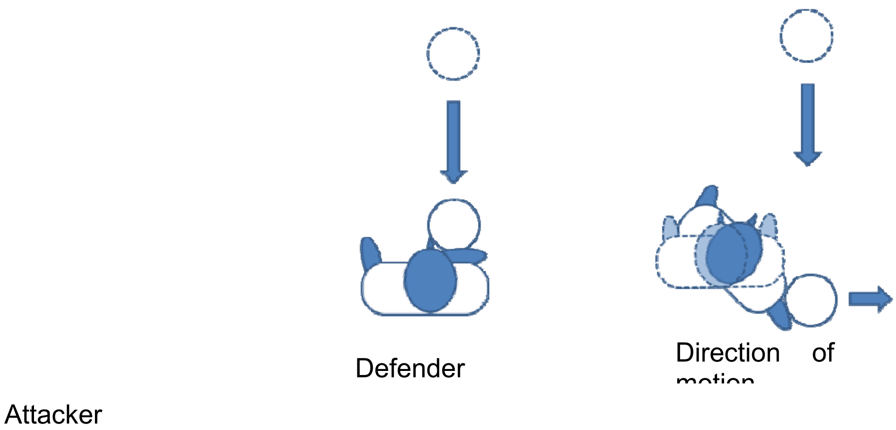
INTRODUCTION: In soccer, ball-trapping skills have the same importance as kicking skills. It could be said that trapping, in which the ball is stopped using the inside of the foot, is the most frequently used skill. The movement that results in stopping the ball while changing the direction of the body is an especially important technique in the game. However, little research has been devoted to ball trapping. Although Asai et al. (1981) studied inside trapping dynamically using a cinematographic technique and an accelerometer, the experiment involved stopping a ball that was suspended from the ceiling and swung toward the subject; thus, this could not be said to reflect the actual situation in the game (Asai, Kobayashi & Matsumoto, 1981). The purpose of the present study was to extract motion characteristics closely related to inside trapping in soccer from the changes in foot acceleration, ball velocity after trapping, and lower-limb joint angles during trapping.

METHODS: Thirteen experienced male collegiate soccer players (18.3 ±0.49 y; 1.73 ±0.06 m; 60.6 ±4.86 kg; athletic career 11.0 ±2.6 y) were asked to perform inside trapping 10 consecutive times with the following two tasks: (1) trapping the ball in front of the foot; (2) trapping the ball at an angle (90° to the right) (Figure 1). These tasks were conducted with the ball kicked at random speeds 7 m away from the experimental subjects. Two triaxial accelerometers (1000 Hz) were fixed under the lateral malleolus (LM) and on the lateral side of the fifth metatarsal bone (FMB) (Figure 2). The motion of the whole body during trapping was recorded using two high-speed video cameras (200 Hz) synchronized with accelerometers. One camera was about 10 m behind and 10 m to the right of the ball; the other was 6 m in front and 10 m to the right of the ball. The locations of 28 body landmarks and the center of the ball were digitized manually in each frame from 10 frames before ball impact and 10 frames after ball impact.

To determine the joint angle, right-handed orthogonal reference frames were used for the foot, shank, and thigh of the kicking leg. The foot axis was defined as the vector from the ankle to the second metatarsal bone; with this axis, the foot reference frame was defined such that the x axis was the foot axis, and the xy plane was defined by the foot axis and the FMB. The shank axis was defined as the vector from the ankle to the knee; with this axis, the shank reference frame was defined such that the y axis was the shank axis, and the yz plane was defined by the shank axis and the LM. The thigh axis was defined as the vector from the knee to the hip; with this axis, the thigh reference frame was defined such that the z axis was the foot axis, and the yz plane was defined by the thigh axis and the fibular bone. The joint angles were expressed as Cardan angles (Kawamoto, Miyagi, Ohashi & Fukashiro, 2007).

Maximal foot acceleration at ball impact, the lower-limb joint angle at ball impact, and the ball velocity were used for the analysis. Ball velocity was taken as the synthesized velocity immediately before and immediately after ball impact.

Pearson's product-moment correlation coefficients were used to determine statistical relevance among the variables. The criterion for statistical significance was p <0.05 for all analyses.



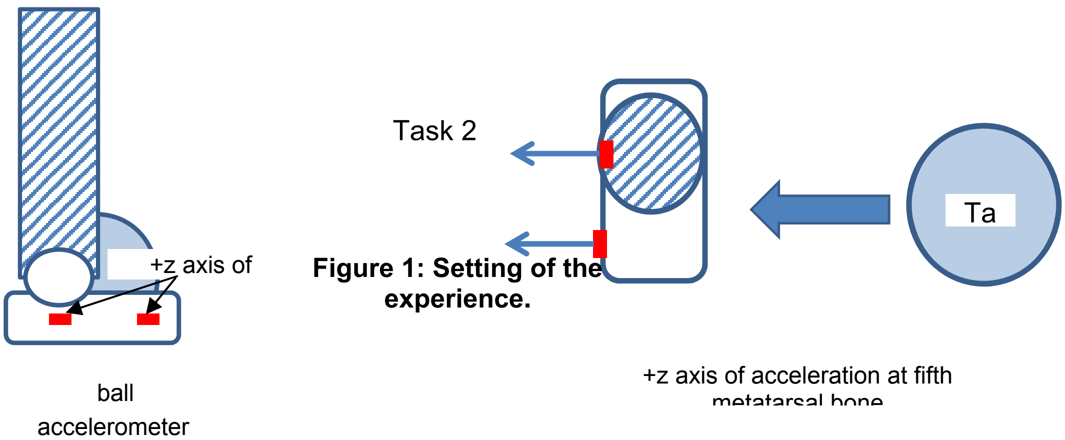


Figure 1: Setting of the experience.

RESULTS: With the first task, the mean ball velocities for immediately before and immediately after ball impact were 15.4 ±3.5 m/s and 1.5 ±3.5 m/s, respectively. With the second task, the mean ball velocities for immediately before and immediately after ball impact were 15.0 ±3.3 m/s and 2.0 ±0.9 m/s, respectively. The results of the acceleration of the foot and the joint angle of the lower leg were shown in Table 1.

There was a significant negative correlation between ball velocity after trapping and external rotation of both the hip and knee when trapping the ball in front of the foot (hip, r=-0.62; knee, r=-0.65; $p<0.05$ for both coefficients). In the same task, there was a significant correlation between maximal acceleration toward the z axis of the LM on ball impact and external rotation of both the hip and knee (hip, r=0.51; knee, r=0.58; $p<0.05$ for both coefficients). When trapping the ball at a 90° angle, there was a significant negative correlation between ball velocity after trapping and external rotation of the hip (r=-0.66; $p<0.05$). There was also a significant correlation between maximal acceleration toward the z axis of the FMB at ball impact and external rotation of the hip (r=0.48; $p<0.05$).

The leg view from the side.

Variables	Trapping in front foot	Trapping with rotation by 90 degrees
Maximal acceleration toward z axis of LM (m/s^2)	41.8±9.3	-190.2±9.3
Maximal acceleration toward z axis of FMB (m/s^2)	264.2±11.1	295.5±9.5
External rotation of hip (degree)	21.5±4.4	30.1±2.3
External rotation of knee (degree)	29.0±2.2	12.1±1.0
Abdution of hip (degree)	28.5±2.9	29.1±1.9
Flexion of hip (degree)	22.7±6.2	24.3±5.0
Flexion of knee (degree)	39.0±4.5	36.6±3.6

DISCUSSION: After trapping, the ball did not always come to a complete stop; it sometimes retained some velocity. Usually, in practice, a ball is controlled such that the next move in play can be easily executed. Therefore, it is considered that the results in the present study reflect the fact that the subject was simulating trapping in the practical situation of play. This is also suggested by the ball velocity in the second task, which was greater than in the first task. Since in trapping the ball velocity is purposely reduced, it is believed that trapping controls the ball in a manner that facilitates the next movement with the ball.

We supposed that the position of ball contact in ball trapping changed according to the task as a result of acceleration. In other words, in the task of trapping the ball in front of the foot, we believed that the ball was stopped at a position near the foot's center of mass, since the acceleration of the LM was greater than that of the FSB. On the other hand, in the task of trapping the ball at an angle, we considered that the ball was stopped at a position closer to the toe side rather than the foot's center of mass, since the acceleration of the FSB was greater than that of the LM.

There was a significant negative correlation between ball velocity after trapping and external rotation of both the hip and knee when trapping the ball in front of the foot. And when trapping the ball at a 90° angle, there was a significant negative correlation between ball velocity after trapping and external rotation of the hip. These results suggest that in the action of trapping, external rotation of the hip affects the impact absorption of the ball and controls ball velocity. Moreover, in the first task, we deduced that external rotation of the knee was participating in the impact absorption of the ball. We considered that rather than active movement, external rotation of the knee occurs when the ball is struck, and this also involves the use of the lower thigh to a lesser extent. To carry out external rotation, the angle of the knee must be 30° or more. The angle of the knee measured in this study was the result of the knee making this accommodation.

In the first task, absorbing the shock of the ball by partly using the lower thigh can also be deduced from the correlation between the external rotation angle of the knee and the acceleration of the LM. The fact that external rotation of the knee is responsible for absorbing the impact of the ball and decreasing its velocity is evident from the ball velocity. In the second task, since there was a correlation between the external rotation angle of the hip and the FSB, we consider that the ball impact was absorbed by a different mechanism from that in the first task. We suggest that absorbing the ball impact was absorbed by eversion of the ankle and external rotation of the hip rather than external rotation of the knee.

CONCLUSION: Our findings suggest that inside trapping of the ball in soccer is associated with the large external rotation angle of the knee and the hip, and these decrease the ball's velocity. In trapping the ball at a 90° angle, we determined that the ball can be effectively stopped by changing the position of its contact with the foot through external rotation of the hip.

REFERENCES:

Asai, T., Kobayashi, K. & Matsumoto, M. (1981). A biomechanical study of ball stopping skills in soccer. *Japanese Society of Physical Education*, 26(3), 245-251.

Kawamoto, R., Miyagi, O., Ohashi, J. & Fukashiro, S. (2007). Kinematic comparison of a side-foot soccer kick between experienced and inexperienced players. *Sports Biomechanics*, 6(2), 187-198.

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