

BALL IMPACT DYNAMICS OF INSTEP KICKING IN SOCCER

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INTRODUCTION

There are a variety of collisions in sporting activities. In soccer, the most typical and important collision is that of ball impact during kicking. However, as the ball contact time is very short (typically less than 10 ms), the number of studies that have enough kinematic sampling rate to capture the foot and ball motion during ball impact is limited. To date, three dimensional foot motion associated with the ball deformation have never been illustrated adequately.

It is reasonable to assume that the foot motion during ball impact is passively caused by the reaction force acting from the ball. However, no study has attempted to calculate the peak reaction force directly from the ball deformation and the displacement of its center of gravity during ball impact using a fast enough high-speed sampling image of ball kicking.

Recently, we made an attempt to reveal the above research questions [1]. The findings will be summarized in this paper.

METHODS

22 maximal instep kicks performed by eleven skilled footballers were selected for analysis. A FIFA-approved size five soccer ball (mass = 0.43 kg, inflation = 900 g/cm) was used. All subjects wore the same type soccer shoes for indoor. Two electrically synchronized ultra high-speed cameras were used to capture the foot, the lower leg, and the ball motion at 5000 Hz.

The foot motion was illustrated three dimensionally (plantar/dorsal flexion, abduction/adduction, inversion/eversion). The motion of the ball center of gravity (CGB) during ball impact was obtained by the spherical shell model, in which the ball deformation was taken into account. Moreover, the peak ball reaction force acting on the foot was estimated from Newton's equation of motion in which the peak CGB acceleration was calculated from its velocity slope near the time of peak ball deformation.

RESULTS AND DISCUSSION

During ball impact, the foot was passively abducted and everted. Moreover, several different changing patterns were observed for the foot plantar/dorsal flexion (Figure 1). In most trials (21 of 22 trials), the foot was kept its angle (pattern A) or slightly flexed dorsally (pattern B) before distinctive plantar flexion. A unique feature was also detected for particular one trial: the foot continued to be flexed dorsally throughout the ball impact (pattern C). The foot orientation and ball contacting point may account for these differences.

Figure 2 shows the average change of the linear velocity of the foot and CGB, and ball deformation just before, during and just after ball impact. From these changes, the ball impact phase, although it continued 9.0 ± 0.4 ms, can be divided into four phases. Phase I can be defined from the

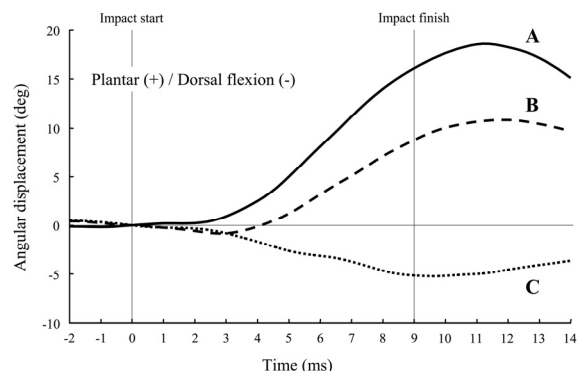


Figure 1: Three typical patterns of changes of foot angular motion in plantar/dorsal flexion during ball impact phase.

instant of ball contact while the CGB began to move together with the ball deformation, whereas the opposite ball edge did not move. Phase II begins when the whole ball began to move forward and lasts until the ball velocity exceeds that of the foot velocity (correspond to the time of peak ball deformation). Phase III followed and ends when the CGB velocity is being almost plateau (reached at 95% of launching velocity). Finally, Phase IV subsequently occurred and ended when the foot loses its contact with the ball. In this phase, it was considered that the dynamical interaction between the foot and ball was very small. The peak ball reaction force was 2926 ± 509 N which is substantially larger than those reported previously [2,3].

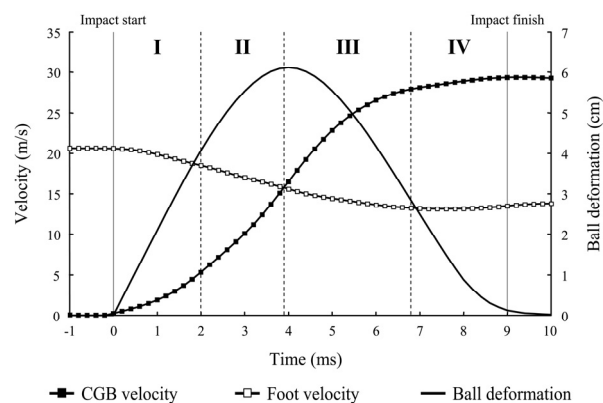


Figure 2: Aspect of foot-ball interaction during ball impact.

CONCLUSIONS

The ultra high-speed video and methodology in this study documented complex three-dimensional foot motions to impact in soccer instep kicks, dynamic foot-ball interaction, and larger peak ball reaction force on the foot that previously estimated. Of these, it can be considered that effectual duration to accelerate the ball is roughly three fourths of visually ball contact time.

REFERENCES

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