BALL IMPACT ANALYSIS IN FOOTBALL USING FEM FOOT MODEL

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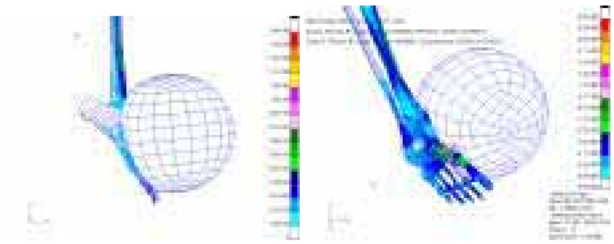
INTRODUCTION

The motion analysis of kicking in football has been studied by several investigators. However, there are few studies that analyzed the interaction of the kicking foot and ball at impact in football. The purpose of this study is to clarify the relation between the stress distribution, the deformation and the impact point on the foot using a finite element skeletal foot model.

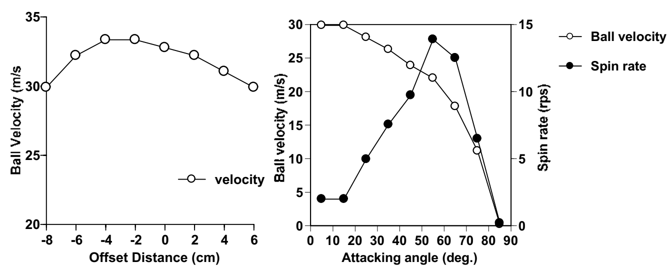
METHODS

The basic shape of the finite element skeletal foot joint model was described using a commercial foot skeletal model for computer graphics and anatomical data, and the solid model was defined after simplifying that model (Fig. 1). The Young's modulus of hard tissue parts was 15GPa and the Poisson's ratio was 0.3 [1], The Young's modulus of soft tissue parts was 1500 MPa and the Poisson's ratio was 0.3 [2]. In the analysis of the ratio of restitution on the foot complex at impact using the instep kick model, the impact point was defined from the axis of the ball –80 to +60 mm at intervals of 20 mm in the vertical direction. The ball velocity and the direction of the ball trajectory after impact were compared by each vertical offset distance. In the curve kick analysis, the generation of spin depends upon the attacking angle and the impact point of the foot on the ball in relation to the axis of the ball. The simulations were carried out with a fixed coefficient of friction of 0.4 with attacking angles from the axis of the ball 5 to 85 degrees at intervals of 10 degrees.



(a) (b)

Figure 1: The instep kick model (a) and the curve kick model (b) using finite element skeletal foot model.



(a) (b)

Figure 2: The relation between offset distance and ball velocity (a) and the relation between attacking angle and ball velocity (b).

RESULTS AND DISCUSSION

In the instep kick analysis using the finite element skeletal foot model, high intensity stress (about 50 MPa) was seen in metatarsal, cuneiform, navicular and tibia at impact. The ball velocity after impact with an offset distance of -20 mm was 33.4 m/s, and that for the offset distance of +20 mm was 32.2 m/s. The maximum ball velocity after impact in this simulation was for the offset distance of -20 mm and –40 mm, while the minimum ball velocity was for the offset distance of +60 mm and -80 mm (Fig. 2(a)). These was a tendency that the deformation of the foot joint in the lower impact case was greater than that of the higher impact case. It is suggested that the energy dispersion of the foot for the lower impact case is greater than that for the higher impact case. The direction of the ball trajectory after impact (shoot angle) in each case indicated a nonlinear trend. The maximum shoot angle was 16 degrees for the offset distance of -20 mm. It seems that the shoot angle was influenced by the location and the deformation of the foot complex and the ball. The relation between attacking angle and ball velocity and the relation between attacking angle and spin rate are shown in Fig. 2(b). It was found that the spin rate of the ball generally increases as attacking angle is increased, but the spin rate falls rapidly in the case of the attacking angle being 75 degrees or greater. The ball velocity simply decreases as the attacking angle is increased. Hence it is considered that, for the infront curve kick, a foot orientation at impact, with the attacking angle between the face vector and the swing vector generates the optimum moment with which to generate ball spin.

REFERENCES

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