KINEMATIC ANALYSIS OF SOCCER HEADING; COMPARISON OF TRAINING METHODS

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INTRODUCTION
Soccer is one of the most popular sports in the world. Heading is a technique of hitting a soccer ball using the head. There are several training methods to improve the heading technique. The most popular training method of the heading is heading the thrown ball. In this method, the ball is passed to the trainee directly; therefore, trajectory of the ball is similar to that seen in soccer games. However, reproducibility of the throwing is of concern. Another training method is that using a pendel to create motion of the ball [1,2]. This method employs simple equipment to hang the ball by rope. The ball moves like pendulum; therefore, its trajectory may not exactly duplicate the actual trajectory of the ball in the soccer game. However the pendel can create the ball trajectory with high reproducibility. The purpose of this study was to investigate differences of the heading motion between aforementioned two training methods.

METHODS
Thirteen university students were employed for this study (IRB approved). All subjects were skilled players with experiences of soccer of 12.9±2.9 years. Average age, height and weight of the players were 21.5±1.2 years old, 172.1±6.0 cm and 64.9±2.9 kg, respectively. A total of 55 spherical reflective markers were used (49 markers on subject’s body, and 2 markers on a ball). 3D positions of each marker were recorded by a motion capture system (MAC 3D system, Motion Analysis). Three local coordinate systems were defined on the pelvis, thorax and head of the player’s body to investigate kinematic parameters. Angular displacement of the head, thorax, and pelvis were calculated using coordinate transformation and Euler angles. Since a predominant heading motion is bending of the thorax, joint angles and angular velocity of forward and backward bending of the head and thorax were measured in this study. The period of heading motion was normalized by the period of the heading procedure. The start of the period (t=0[%]) was defined as the timing when subjects maximally bent the body backward. The end of the period (t=100[%]) was defined as an instance of ball impact. All subjects headed the soccer balls using two ball pass methods. First, the ball was passed to the subject by throwing with hands. The same passer threw the ball to the subject from a location 3 meters away from the subject. The subject was indicated to head the ball toward the passer. Next, the subject headed the ball using the pendel (Fig. 1). Ball height was adjusted according to the head position of each subject. The subject pushed the ball by him/her-self, moved back several steps, approached and headed the ball. The heading motion was recorded ten times in each method. The kinematic parameters in two methods were compared with a t-test. Significant level was set at p<0.05.

RESULTS
Significant difference was found in head backward tilt angles at both start (t=1) and end (t=100) of the heading period (Table 1). However, no significant difference was found in both thorax backward tilt angles (Table 1). In addition, no significant difference was found in each range of motion (Fig. 2).

Figure 1: The experimental setup of the pendel
No significant difference was found in average angular motion and maximum angular velocity of head motion during the heading period (Figs. 3, 4). However, significant difference was found in average angular velocity and maximum angular velocity of thorax motion (Figs. 3, 4). No significant difference was found in height of ball impact (Table 2). However, significant difference was found in ball velocity just before impact (Table 2).

**DISCUSSION**

The present study showed more forwarded head position in the pendel method. This finding suggests that subject's visual axis was different in two methods. Training using the pendel may have made the players’ view axis lower than that in the throwing training, which may caused lower angular velocity of the thorax in the pendel method.

If the ball velocity could be adjusted to the same velocity between pendel and throwing training methods, angular velocity of the thorax with the pendel may be same as that in the throwing method. However, there is an essential difference in the parabolic trajectory between the two methods (with a convex upward in the throwing method and a convex downward in the pendel method), and it may affects the motion tracking by the player. Therefore, the pendel may not be suitable for heading training. Nonetheless, the pendel method may be still suitable for beginners who afraid of the heading. It is natural for a human to be afraid of hitting a ball moving towards him/her with his/her head. Therefore, the first step of the heading is to overcome this fear. Due to lower velocity of the ball and no significant difference in the range of motion in the training using the pendel as compared with the throwing method, the pendel method is an effective training method for beginners. After the players have overcome the fear of heading, they may need to practice heading with the throwing ball.

**REFERENCES**