INTRODUCTION

The kip maneuver at the horizontal bar is one of the important skills in gymnastics and also is difficult for beginners to learn and execute. Most of the studies on the kip maneuver compared the execution of the skilled subjects with the unskilled ones. There is little information on effects of the technical training on the performance of the kip maneuver. The beginners will try to execute the kip maneuver in the similar pattern movement of skilled performers as a learning model. The similarity between the performances of the beginners and the skilled performers can be an index of the degree of skill level and learning process. The purpose of this study was to investigate the change in the similarity of joint angle and torque patterns during the technical training of the kip at the horizontal bar.

METHODS

Collection of model data

Ten varsity gymnasts as skilled subjects performed the kip maneuver at the horizontal bar. Their maneuver was videotaped in the sagittal plane with a VTR camera (60Hz). Eleven body landmarks and the center of the bar were digitized. The coordinates data were smoothed with a fourth order Butterworth digital filter with cut off frequencies ranged from 3 to 6 Hz which were determined by the technique of Wells and Winter (1980). Kinematics and kinetics were calculated by a motion analysis technique.

The data were normalized by the time between the instant that the CG passed under the bar in the forward swing and the instant comparable in the backward swing, and averaged. The normalized time was converted into actual time on the basis of the average time.

Technical training

Three male subjects with no experience of performing the kip maneuver were selected as unskilled subjects. They practiced the kip maneuver at the horizontal bar for 5 to 12 days, depending on the progress of the training of the subjects. VTR image of the kip maneuver by the skilled subject was shown at the beginning of the practice and the time as necessary.

Data analysis

All the trials were videotaped with a VTR camera (60Hz). Trials of every five were selected to analyze biomechanical variables in the course of the practice. Kinematics and kinetics were calculated in the same manner as the case of skilled subjects. Correlation coefficient was calculated in the shoulder and hip joint angles and torques between the unskilled subjects and the skilled ones to examine the similarity of the patterns of the variables. Change in correlation coefficient with practice was tested using regression analysis (p < 0.05).

Figure 1: Kip maneuvers of the skilled subject and the successful, midpoint, and first trials of a typical unskilled subject (sampling 0.1 s). The skilled kip maneuver was normalized by time and the subject’s body height and averaged using the technique by Ae, et al. (1997).
RESULTS

Figure 1 shows the sequences of the kip maneuver for the skilled subject (top figure), and the successful, the midpoint and the first trials of a typical unskilled subject. The timing of the motion in the successful trial for the unskilled subjects was different from that of the skilled subjects in the first half. The skilled subjects kept the straight body position until 0.4 s, flexed the hip joint at about 0.9 s, and extend the shoulder and hip joints at about 1.2 s. The unskilled subjects began the shoulder extension and the hip flexion before 0 s. At the first and the midpoint trials, the unskilled subjects clearly flexed not only the hip, but also knee joints during the first half. The hip flexion of the unskilled subjects was small, and the timing of the extension was earlier in the first trial.

Figure 2 shows relationships in the joint angles and torques of the shoulder and hip between the number of trials and the correlation coefficients which were calculated between the patterns of the variables in the unskilled and skilled subjects. Correlation coefficient of the shoulder joint angle was higher than the hip. Correlation coefficients of the shoulder and hip joint angle significantly related to the number of trials (p < 0.05) except the hip joint angle of subject B. Change in correlation coefficient of the shoulder joint torque was very varied and most of the coefficient were negative. Correlation coefficient of the hip joint torque of subjects B and C significantly increased with the increase in the number of trials (p < 0.05), and coefficient of subject A was high in the second half of the training period.

Figure 3 shows the changes in the shoulder and hip joint angles and torques in successful trial of the unskilled subjects and the skilled one. The patterns of the shoulder joint angle were similar in all subjects. Flexion of the hip joint occurred in the skilled subject in later time than those of the unskilled ones, as mentioned before. All the subjects kept exerting the shoulder extension torque in almost whole phase. However, the skilled subjects showed the peak shoulder extension torque at about 0.8 s, while the timing of the peak shoulder extension torque of the unskilled subjects was variant and, roughly speaking, the pattern was opposite to the skilled subjects. The pattern of the hip joint torques in the second half were similar in both groups, but the timing of the appearance of the peak flexion torque in the first half was different.

DISCUSSION

At the kip maneuver the shoulder joint was continuously extended, while the hip joint was flexed to put the feet in the closer position to the bar, and then extended. The change in the shoulder joint angle showed a simpler pattern than that of the hip joint angle. The peak of the flexion of the hip joint for the unskilled subjects appeared in a different timing from that of the skilled subjects, and the pattern from 0 to 0.8 s was also different. The earlier peak flexion of the hip joint of the unskilled will be one of the reasons why correlation coefficient of the hip joint angle was lower, especially in subject B. Because of the remarkable difference in the pattern of the flexion torque of the shoulder joint between the unskilled and the skilled subjects, the correlation coefficient of the shoulder joint torque was negative and so varied.

Although the correlation coefficient of the shoulder joint angle increased with the increase in the number of trials, that of the shoulder joint torque did not change consistently. The correlation coefficient of the hip joint angle and torque were related to the number of trials. The clear change by the technical training of the kip maneuver was the change in

![Figure 2](image_url): The relationships in the shoulder and hip joint angles and torques between the number of trials and the correlation coefficients which were calculated between the unskilled and the skilled subjects.
patterns of the hip joint angle and torque during the hip extension phase in the second half. This suggests that it is important for the unskilled subject to give attention to the extension of the hip joint and extension of the torque.

The patterns of the joint angles and the torques of the unskilled subjects became closer to those of the skilled one as the progress in the technical training, but the correlation coefficient in even successful trials was still low. This result has two-fold meanings: the first is that there may be diverse patterns of the shoulder joint torque exertion even if the patterns of the joint angle seem to be similar; the second is that the shoulder extension torque may be less important than expected, which is always emphasized in learning of the kip maneuver.

REFERENCES
