A BIOMECHANICAL STUDY ON IMPROVEMENT IN THE OVERARM THROWING TECHNIQUE OF ELEMENTARY SCHOOL CHILDREN

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The purpose of this study was to investigate the improvement in technique of the overarm throwing due to a training with the standard motion model in elementary school children. Thirty-two children from the sixth grade were participated in three sessions: the pre- and post-training videotaping and throwing technique training sessions. Their throwing motions were videotaped with two high-speed cameras and analysed three-dimensionally. Through the training with the use of the standard motion model as a reference, the throwing distance and release parameters significantly improved. The throwing motion changed to be similar to the standard motion model after the training. The results indicated that the use of the standard motion model was useful for the improvement in the throwing techniques and throwing distance of less experienced children.

KEY WORDS: standard motion, delayed display, technique learning.

INTRODUCTION: In physical education class of the elementary schools in Japan, one of the essential tasks in teaching is to provide an appropriate motion pattern as a reference and to help children intuitively understand a good motion pattern to be learned. However, this approach has some limitations: there is motion variability in a model technique attributed to a model person's property, there is no firm or valid base for appropriate motion models.

For an effective teaching of sports technique, we need to prepare appropriate motion models of sports techniques. Ae, Muraki, Koyama & Fujii (2007) proposed a method to provide a standard motion model as an averaged motion pattern for skilled performers. Kobayashi, Ae, Miyazaki & Fujii (2011) established overarm throwing models composed of the skilled elementary girls and revealed that different standard motion models of the overarm throwing should be provided for different grades.

Although the use of the standard motion model seems to be effective in teaching sports techniques, there is no investigation on effects of the standard motion model on technical learning of the overarm throwing. Therefore, the purpose of this study was to investigate the improvement in performance and technique of the overarm throwing due to a training with the standard motion model in elementary school children.

METHODS: Seventeen boys (age, 12 yrs; height, 1.46 ± 0.07 m; weight, 39.62 ± 10.03 kg) and fifteen girls (age,12 yrs; height, 1.46 ± 0.06 m; weight, 38.35 ± 5.84 kg) from the sixth grade of one elementary school participated in three sessions in this study: the pre- and post-training videotaping and throwing technique training sessions. They were instructed to throw a softball (8.5 cm in diameter; 141 g in mass) twice with their maximal effort in physical education lessons, according to the procedure of the Japan Fitness Test regulated by the Japanese Ministry of Education, Culture, Sports, Science and Technology. The regulation specifies the ball size and weight, and prescribes that one longer throw of two trials be adopted as a best performance. The throwing motion of the subjects was videotaped in the pre- and post-training sessions for comparison with two high-speed digital cameras (Exilim EX-F1, Casio Co., Japan) operating at 300 Hz, which were synchronized by a light-emitting diode synchronizer.

The subjects participated in the throwing technique training session once a week, 45 minutes a day, for three weeks. The first part of the training consisted of instruction of the standard motion model explained by the investigators (Figure 1a), and observation of children's own throwing motion by using a delayed display webcam (Figure 1b, c). The second part included several throws of a softball to the ground or against the wall, throws from a run-up and throws for distance, totally about 30 times for each subject. In the technique training session, the standard motion model established by Kobayashi et al. (2011) was adopted as a reference, which was the normalized and averaged motion pattern of seven skilled girls of the sixth grade (age, 12 yrs; height, 1.45 ± 0.05 m; weight, 35.90 ± 5.96 kg; throwing distance, 21.24 ± 4.14 m), as shown in the top of Figure 2.

Based on the change in the throwing distance due to the training, typical throwers were selected for the analysis of effects of the technique training. Twenty-three body landmarks and the centre of the softball were digitized with a digitizing system (Frame-DIASⅡ, DKH Co., Japan). Three-dimension coordinate data were reconstructed by the DLT method and were smoothed by a Butterworth digital filter with cut-off frequencies ranging from 7.5 to 12.5 Hz which were decided by the residual method after Winter (2009).

The height, velocity and release angle of the ball at the release, kinematics of the upper and lower limb joints and trunk were computed. The z-score was calculated as an index of motion deviation from the standard motion model using the following equation (Ae et al., 2007).

$$d_i = \frac{x_i - M_i}{SD_i},$$

where d_i is the z-score (motion deviation), x_i is the kinematic data for the pre- or post-training at time i, and M_i and SD_i represent mean and standard deviation of the standard motion model at time i.

The throwing motion was divided into the striding and throwing phases. The striding phase was defined from the instant of the lowest ball height to the stride foot contact, and the throwing phase was from the stride foot contact to the instant of the ball release. Time series data were normalized as 100% time for each phase, totally as 200% time.

Paired *t*-test was used to test differences between the pre- and post-training session with the significance level set at 5%.

RESULTS: The throwing distance for the post-training session was significantly larger than that of the pre-training (boys, pre-training 28.4±8.4 m, post-training 31.6±10.8 m, t_{16}=3.21, p=0.002; girls, pre-training 16.0±4.3 m, post-training 17.0±3.4 m, t_{14}=1.83, p=0.04).

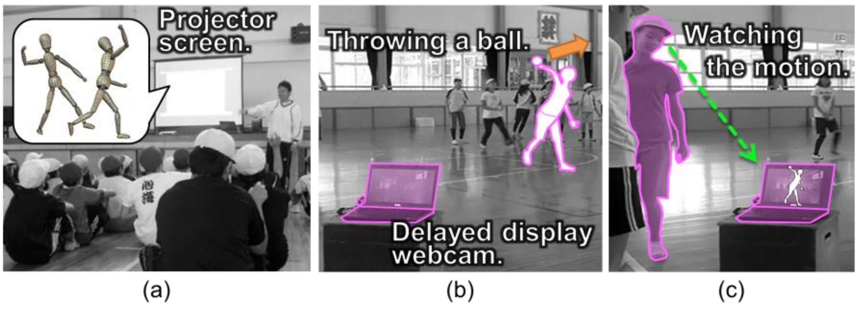

Figure 1: Scenes of the first part of the technique training session.

The throwing distance, ball velocity, release angle and height of subject A as a typical one at the post-training session were greater than those of the pre-training, as shown in Table 1.

The motion at the post-training session was similar to the standard motion model: the right shoulder joint was abducted about 90º (100% time), the right knee joint was largely flexed in the striding phase and was extended in the throwing phase, and the trunk was greatly rotated forward at the ball release, as shown in Figure 2.

As shown in Figure 3, the elbow joint flexion around 180% time of the data from the pre-training session was larger than that of the post-training session, and the z-score of elbow joint for the pre-training session was greater in negative than -1.0 in corresponding period. The z-score of the trunk rotation angle for the pre-training session deviated from a range of one standard deviation in the second half of the throwing phase.

Table 1: The throwing distance, ball velocity, release angle and release height at the pre- and post- training sessions for subject A.

	Throwing distance [m]	**Ball velocity** [m/s]	**Release angle** [º]	**Release height** [m]
Pre-training	10.0	9.0	28.4	1.73
Post-training	13.5	11.3	29.9	1.80

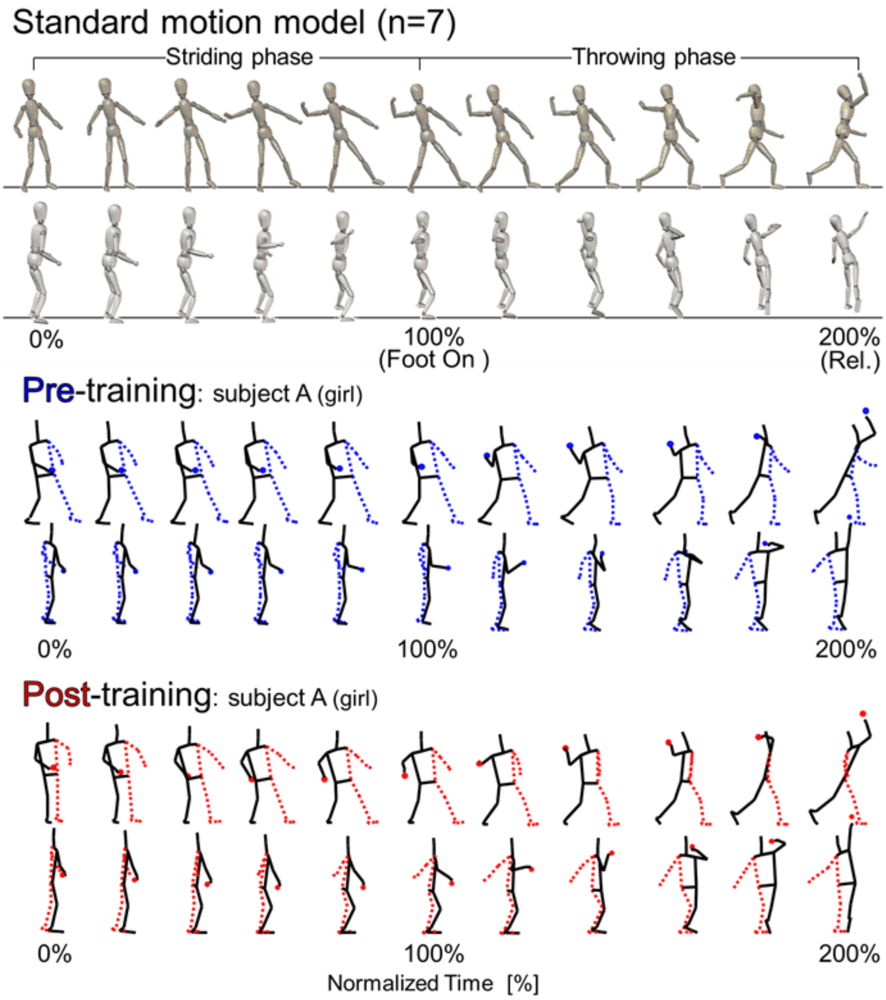

Figure 2: Stick pictures of the standard motion model of the throwing for the skilled girls and the pre- and post- training sessions for subject A from the lowest ball height to the ball release.

DISCUSSION: The throwing motion of subject A at the post-training session seems to be closer to the standard motion model (Figure 2). Andrew & Paul (2005) remarked that motor learning in reaching movement occurred even in the absence of explicit movement by observing actions of other subjects, and indicated that information on movement kinematics, acquired from visual information alone, must have been transformed into a representation of forces and subsequently a required change to neural control signals for movement. It can be inferred that the subjects in the present study recognized differences between their own throwing motion and the standard motion model by observation of both motions, and tried to change their motion for imitating the standard motion mode through the visual feedback and the throwing drills at the training session. This will contribute to the acquisition of the throwing technique and explain the significant increase in the throwing distance.

Although the trunk rotation angle at the pre-training session was much smaller than the average in the second half of the throwing phase, the large trunk forward rotation before the

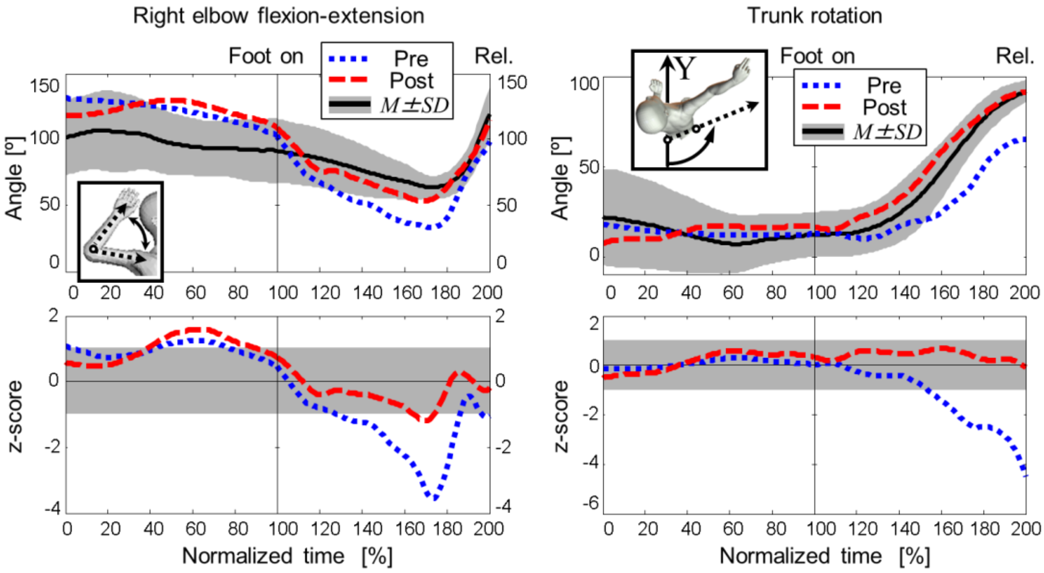

Figure 3: Changes in the elbow joint and lower trunk rotation angles (top) and the z-score (bottom) between the pre- and post-training sessions for subject A. The black solid line and shaded area indicate the averaged angle and the range of one standard deviation, respectively.

release was appeared at the post-training session, which had been considered to associate with the maturation of child's throwing motion (Roberton, 1977). The increase in the trunk rotation can be attributed to the increase in the range of motion of the right lower limb, as seen in Figure 2.

Roberton (1977) noted that the primary shoulder joint action for nearly half of 727 trials in normal children aged 6.4 to 8.0 years old was adduction and abduction. Leme & Shambes (1978) revealed that the adult women subjects who threw a ball in slow velocity exhibited immature throwing patterns which were directly analogous to the more primitive so-called "stages" previously identified in young children. From these remarks and the results, it can be said that the motions of the trunk and limbs at the pre-training session have been immature. However, the throwing motion of the subject was improved as a result of the throwing technique training. These facts revealed that the use of the standard motion model as a reference in teaching was likely to be effective for improving the throwing performance and correcting false motions.

CONCLUSIONS: Through the technique training of the overarm throw, the throwing distance and release parameters improved in the elementary school children. Their throwing motion at the post-training session changed to be similar to the standard motion model. The results indicated that the use of the standard motion model was useful for the improvement in the throwing techniques and throwing distance of less experienced children.

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