CHANGE IN THE OVERARM THROWING TECHNIQUE DUE TO PRACTICE IN JAPANESE ELEMENTARY SCHOOL GIRLS

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The purpose of this study was to investigate the change in performance and technique of the overarm throwing in elementary school girls through a practice using the standard motion model. Fifteen girls from sixth grade were participated in three sessions: videotaping sessions at the pre- and post-practice and practice session. The throwing motions were videotaped with two high-speed cameras and analysed three-dimensionally. Through the practice using the standard motion model as a reference, throwing distance and ball velocity significantly improved. The trunk forward rotation became similar to that of standard motion model and the mechanical work in the throwing arm increased after the practice. The results indicated that the use of standard motion model was useful to improve the throwing motion as well as throwing performance in elementary school girls.

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

INTRODUCTION: Nelson, K.R., Thomas, & Nelson, J.K. (1991) investigated longitudinal changes in children's throwing motion and found that change in girls' movement pattern from 5 to 8 years old was much smaller than boys. Leme & Shambes (1978) revealed that adult women who threw with slow ball velocity exhibited immature throwing pattern similar to young children. Since the mastery of basic movement skills such as the throwing would be the foundation for an active lifestyle (Gallahue & Ozmun, 2006), it is important to teach appropriate throwing techniques to girls.
For a better technique teaching, we have established a standard motion model of the overarm throwing for the Japanese skilled elementary school girls (Kobayashi, Ae, Miyazaki, & Fujii, 2012). Since the use of the standard motion model is expected to improve teaching basic movements and sport techniques in school physical education class, the effects of the practice using the standard motion model on techniques should be examined biomechanically. The purpose of this study was to investigate the change in performance and technique of the overarm throwing in elementary school girls through a practice using the standard motion model.

METHODS: Fifteen girls (age,12 yrs; height, 1.46 ± 0.06 m; weight, 38.4 ± 5.8 kg) from the sixth grade of one Japanese elementary school participated in three sessions: videotaping sessions in the pre- and post-practice sessions and practice session. They threw a softball (8.5 cm in diameter; 141 g in mass) twice with their maximal effort in physical education classes, 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 mass, and prescribes that one longer throw of two trials be adopted as a best performance. The throwing motion of the participants was videotaped in the pre- and post-practice sessions with two high-speed digital cameras (Exilim EX-F1, Casio Co., Japan) operating at 300 Hz. A light-emitting diode synchroniser was used to synchronise video frames of the movies.
They participated in the practice of throwing once a week, 45 minutes a day, for three weeks as a part of physical education class. The first part of the practice consisted of instruction on the standard motion model explained by the investigators (Figure 1a) and the observation of their own throwing motion by using a delayed display system (Figure 1b and 1c). The second part included several throws of a softball to the ground and/or the wall, throws from a run-up

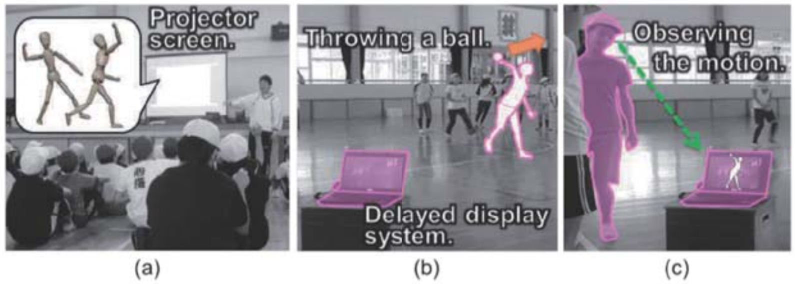

Figure 1. Flow of the technique practice.

and throws for distance, totally about 30 throws for each participant. In the practice, the standard motion model established by Kobayashi et al. (2012) was used as a reference, which was constructed from the averaged three-dimensional coordinate data of seven skilled girls of the sixth grade.

Twenty-three body landmarks and the centre of a softball were manually digitized with a digitizing system (Frame-DIAS II, 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 decided by the residual method.

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, such as joint angle were normalized as 50% time for each phase, totally 100% time.

The height, velocity, and release angle of the ball at the instant of release and kinematic data were obtained from three-dimensional coordinate data. The z-score of joint angles was calculated as an index of motion deviation from the standard motion model using the following equation (Ae, Muraki, Koyama, & Fujii, 2007).

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

where d_i is the z-score at time i, x_i is the joint angle in the pre- or post-practice session, and M_i and SD_i represent mean and standard deviation of the joint angle for the standard motion model, respectively.

The mass, the location of the centre of mass, and the moment of inertia for the participants' body segments were estimated according to the Japanese children's body segment parameters (Yokoi, Shibukawa, & Ae, 1986). The joint forces and torques at the wrist, elbow, and shoulder of the throwing arm were estimated by the equations of motion, and joint force power (JFP) and joint torque power (JTP) were calculated.

The mechanical power of the throwing arm was divided into five mechanical powers: (1) JFP of the shoulder, (2) Trunk-shoulder torque power, (3) JTP of the shoulder, (4) JTP of the elbow, (5) JTP of the wrist. The trunk-shoulder torque power (TSTP) was calculated as an inner product of the shoulder joint torque and angular velocity of the trunk as an index of the mechanical energy flow from the trunk to the upper arm by the shoulder joint torque. The mechanical work was calculated as a numerically integration of the five mechanical powers.

The Wilcoxon signed rank test was used to test for differences in the kinematic and kinetic data between the pre- and post-practice sessions, and the Mann–Whitney U tests was conducted to test differences in joint angles between the standard motion model and the participants in the pre- and post-practice sessions. The level of significance was set at $p<0.05$.

RESULTS: The throwing distance in the post-practice session was significantly larger than that of the pre-practice session (pre- 16.0±4.1 m, post- 17.0±3.3 m, $p<0.05$).

The ball velocity in the post-practice session was significantly greater than that of the pre-practice session (pre- 12.5±2.0 m/s, post- 13.2±1.5 m/s, $p<0.05$).

Figure 2 show changes in the z-scores of the shoulder abduction-adduction, internal-external rotation and the trunk rotation angle in the pre- and post-practice sessions. The z-score of the shoulder abduction-adduction in the post-practice session was within one standard deviation range (Figure 2a), and that of the shoulder internal-external rotation around 180% time was smaller than the pre-practice session (Figure 2b). The z-score of the trunk rotation before the ball release was closer to zero in the post-practice session (Figure 2c).

Figure 3 demonstrates the throwing motions of a girl in the pre- and post-practice sessions which were drawn every 20% time from the stride-foot contact to the ball release. In the post-practice session, the shoulder abduction at the ball release (125°) was smaller than the pre-practice session (150°) and the trunk was greatly rotated forward.

Table 1 show the peak joint torques and forces of the shoulder and elbow joints in the pre- and post-practice sessions. The peak joint torque of the shoulder and peak joint forces of the shoulder and elbow tended to increase after the practice but there were no significant differences.

Figure 4 show the mechanical works due to five mechanical powers during the throwing phase in the pre- and post-practice sessions. The total mechanical work of the throwing arm tended to be larger after the practice (p<0.1). The JFP of the shoulder and TSTP tended to be larger than those of the pre-practice session (p<0.1).

DISCUSSION: The increase in the mechanical work of the throwing arm in the post-practice session resulted in the increase in the ball velocity and the throwing distance. The works done by JFP of the shoulder and TSTP greatly increased after the practice (Figure 4). These indicated that the participants flew large mechanical energy from the trunk to the throwing arm through the joint force and torque of the shoulder in the post-practice session, which could be considered as an effect of the throwing practice.

The large trunk forward rotation during the throwing phase in the post-practice session would increase the angular velocity of the trunk and the shoulder joint velocity and as a result increase the JFP of the shoulder and TSTP. The trunk forward rotation and shoulder

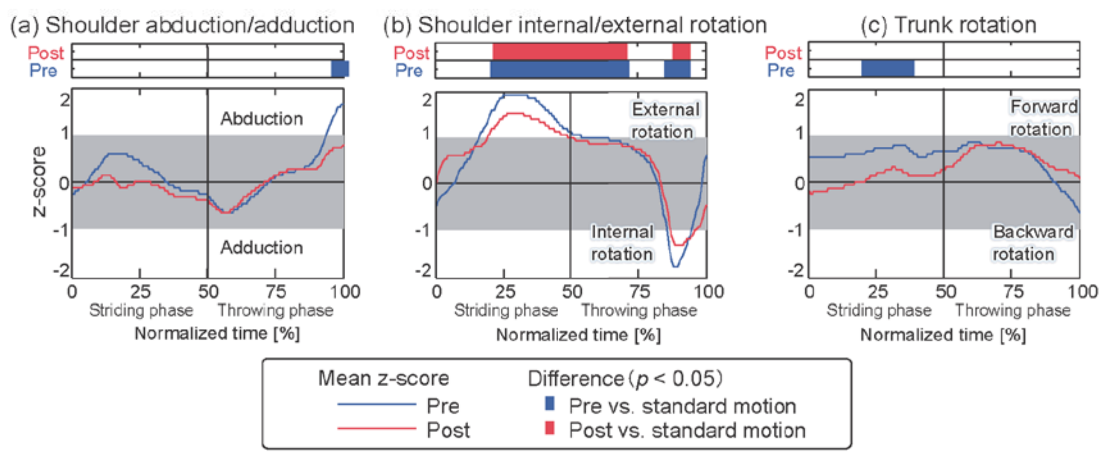

Figure 2. Mean z-score of the shoulder abduction-adduction and internal-external rotation angles and trunk rotation angle in the pre- and post-practice sessions.

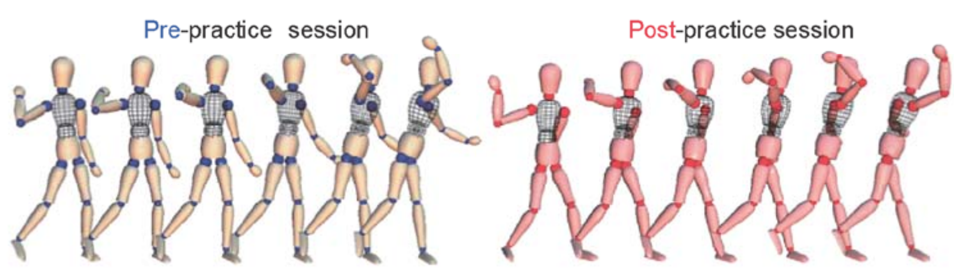

Figure 3. Throwing motion in the throwing phase of a girl in the pre- and post- practice sessions.

Table 1. Peak joint torques and forces of the shoulder and elbow joints.

	Pre	Post
Peak shoulder abduction torque [Nm]	15.5±5.0	15.8±4.3
Peak shoulder horizontal adduction torque [Nm]	19.0±5.8	20.3±4.4
Peak shoulder internal rotation torque [Nm]	14.8±4.0	15.1±4.5
Peak elbow extension torque [Nm]	5.5±2.2	5.3±2.3
Peak shoulder joint force [N]	125.5±24.1	130.2±26.9
Peak elbow joint force [N]	98.5±21.4	101.5±21.8

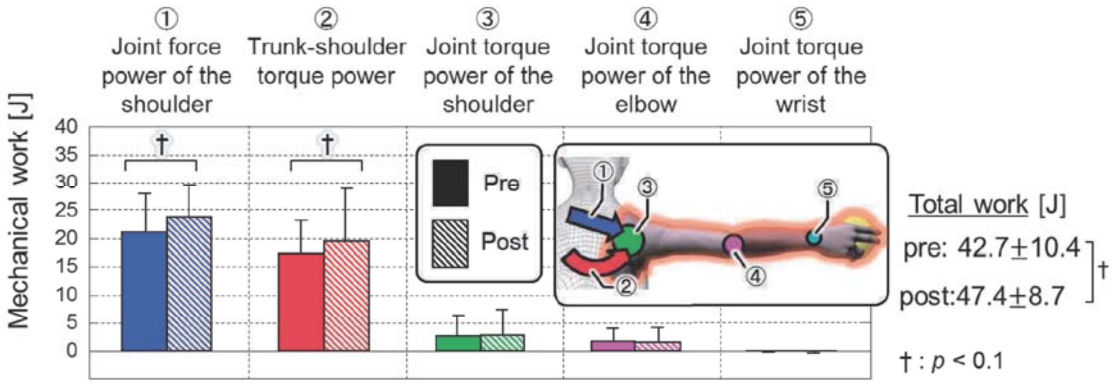

Figure 4. Mechanical works in the throwing phase due to the five mechanical powers of throwing arm in the pre- and post-practice sessions.

abduction that became similar to those of the standard motion model after the practice could enhance the shoulder external rotation before the ball release (Figure 2 and 3).

The participants in the present study would succeed in recognising the difference in the trunk rotation from the standard motion model, and would try to change their motion through visual feedback as well as throwing drills. These revealed that the use of the standard motion model as a reference in teaching could be one of effective means to correct and change the throwing motion in Japanese elementary girls.

CONCLUSIONS: Through the technique practice of the overarm throwing, the throwing distance and ball velocity were significantly improved in the elementary school girls. The trunk forward rotation became similar to that of standard motion model and the mechanical work in the throwing arm increased after the practice. The results indicated that the use of the standard motion model as a reference in teaching was useful to improve the throwing motion and throwing arm joints kinetics as well as the throwing performance in elementary school girls.

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