KINETICS OF DODGEBALL THROWING WITH AN IMPLICATION ABOUT INJURY MECHANISMS OF ELBOW JOINT

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The purpose of this study was to investigate the load of elbow joint based on the kinetic analysis of the primary school dodgeball players' throwing motion. Four male primary school dodgeball players performed the overhand throwing motion while recorded by a Vicon three-dimensional motion analysis system. Changing patterns of elbow joint torques are similar to those for baseball pitching. The varus torque was the largest value among all elbow joint torques . The extension/flexion angle of elbow joint was -64.8° at peak varus torque. It is possible that the varus torque may lead to medial elbow injury, including ligament, muscle, joint surface and ulnar nerve damage. For healthy growth of children, it would be necessary to set some rules for preventing acute and chronic sports injuries, for example, the number of times of throwing in day should be limited.

KEYWORDS: dodgeball, kinetics, injury, primary school, throwing.

INTRODUCTION: Dodgeball is one of the most popular recreational and competitive activities for primary school children in Japan (Wang et al., 2008). The mass of the ball for primary school children is 380g, and is nearly three times of the mass of a baseball. The speed of the ball being thrown is considered to be the most important factor to win the game. It can be estimated that the load at arm joint would be the larger with the larger mass or the faster speed of the ball. The basic method of throwing is overhand, which is similar to the overhand pitching of baseball. The injury in elbow joint is the most frequently occurred injury among the baseball players by the reason of varus torque applied in the elbow joint (Atwater, 1979; Fleisig et al., 1995). We can guess that it is possible for the primary school dodgeball players to suffer the same injury in elbow joint just like baseball players. The purpose of this study was to investigate the load of elbow joint using a kinetic analysis of primary school dodgeball players' throwing motion.

METHOD: Four male primary school dodgeball players (Height=1.37±0.05m, Body mass=30.1±3.2kg, Age=10±0 years, 2-3 years of experience) were used as subjects for this study. All subjects were right-handed with overhand throwing style.
Based on the provision about the ethical guidelines for research on human established by the Ethics Committee of Graduate School of Health and Sport Sciences of Chukyo University, the purpose and the details of this experiment had been explained to the subjects and their protectors before the experiment. The permission to participate the experiment were collected from subjects and the protectors after understanding the details of this study. None of the subjects was found being injured by medical examiner before the throwing experiment. After ordinary warm-up, reflective markers were attached to the skin of anatomical landmarks of the subjects' body, namely, the head of the 3rd metacarpal on the dorsal of the throwing

hand, most caudal-medial point on the ulnar/radial styloid of the throwing arm, most caudal point on medial/lateral epicondyle of the throwing arm, most dorsal point on the acromioclavicular joint of right/left shoulder, anterior/posterior surfaces of the right (left) shoulder overlying the glenohumeral joint, right/left greater trochanter, processus spinosus of the 7th cervival vertebra, processus spinosus of the 8th thoracic vertebra, deepest point of incisura jugularis, processus xiphoideus, most caudal point on the sternum. Two markers were attached on the ball symmetrically, as well. In an indoor testing facility, after comfortable warm-up subjects were requested to throw an official ball (diameter: 0.21m, mass: 0.38kg) aiming at the target 8m ahead until three successful performances were recorded. Three-dimensional motion analysis system (Vicon-MXB, Oxford Metrics Inc., ten cameras, 250Hz) was used to record the locations of the reflective markers.
The best throwing trial evaluated by the subject himself and the coach was selected for analysis. The location data of the markers were smoothed with the fourth-order zero-lag digital filter of the Butterworth type with optimal frequencies (Winter, 1990). Angular displacement of shoulder and elbow joint was calculated with the projecting method (Sakurai et al., 1993). Kinetic values (joint force and torque) were calculated for the elbow joint using the kinematic data, body segment parameters for primary school children (Yokoi et al., 1986), and inverse dynamics procedures (Feltner and Depena, 1986; Fleisig et al., 1995).

RESULTS: A typical example of changes of the elbow joint torques in varus/valgus, extension/flexion and pronation/supination directions were shown in Figure1. Pronation/supination torque fluctuated in the smallest range, and the varus/valgus torque was in the largest. The peak varus torque (17.4 ± 1.9Nm) was the largest among all the elbow joint torques (Table 1), and occurred just before ball release as is the case in baseball pitching.

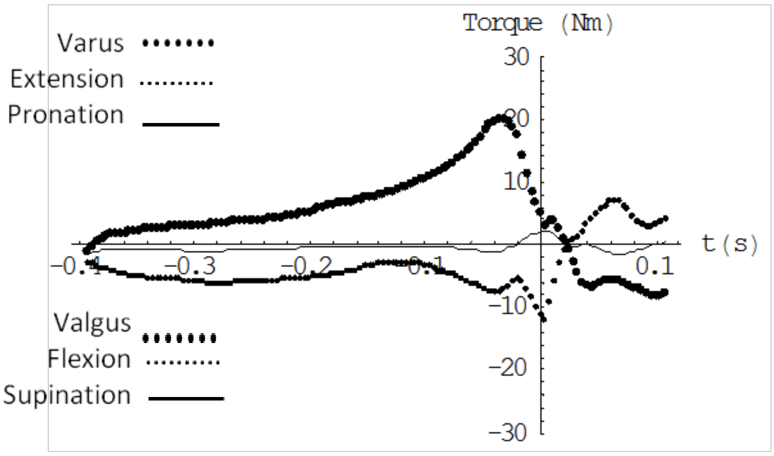

Figure 1. Changes of joint torques at elbow. (The instant of ball release is assigned to t=0.0s)

Table 1. Values of peak torques (Nm) of the elbow joint

	Varus/Valgus		extension/flexion		pronation/supination	
	Max	Min	Max	Min	Max	Min
Torque	17.4 (1.9)	-5.2 (2.3)	4.4 (1.6)	-7.3 (2.7)	1.5 (0.5)	-1.1 (0.3)

Average and (S.D.)

DISCUSSION: For baseball pitching, the load of the ulnar collateral ligament (UCL) due to the varus torque may result in UCL injury (Fleisig et al., 1995). Morrey & An (1983) showed in vitro that when the elbow was flexed 90° and a valgus load was applied to the elbow by the forearm, the UCL generated 54% of the varus torque for resisting valgus motion. While the elbow was extended (0°) , the value was 31%. When the shoulder turned to internal rotation from the maximum external rotation (Figure 2), the peak varus torque (17.4Nm) was applied to the forearm at the elbow joint. At this instant the angle of elbow joint was -64.8° (Figure 2). Assuming the load of UCL from the varus torque is linearly proportional to the elbow joint angle, UCL had generated 8.2Nm when throwing dodgeball. The value (8.2Nm) is clearly smaller than the value in the case of adult baseball pitchers (34.6Nm, Fleisig et al., 1995). However, the force load in UCL is in inverse proportion to the lever arm length of UCL. The lever arm length of children is certainly shorter than for adult. Move over the limit load of UCL rapture for the children could be far smaller than that for adult, which was reported as 32.1Nm by Morrey & An (1983). Varus torque can lead to injuries of muscle or ulnar nerve too (Atwater, A. E., 1979; Fleisig et al., 1995).

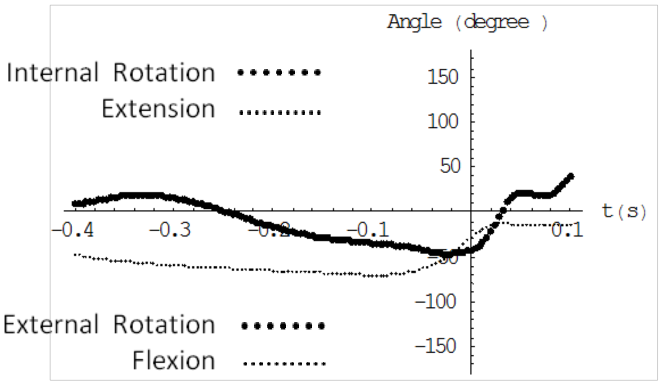

Figure 2. Angular displacement for shoulder Internal/External Rotation and elbow Extension/flexion.

Varus torque can also lead to lateral elbow compressive injury. Morrey & An (1983) reported that in vitro when the elbow was flexed 90°, 33% of the varus torque was caused by the joint articulation. When the elbow was extended (0°), the value was 31%. Assuming the load of joint articulation due to the varus torque is linearly proportional to the elbow joint angle, the torque applied by joint articulation was 5.6Nm for dodgeball throwing motion of the children. Again, the lever arm length is shorter and the strength of bone, cartilage, and soft tissues is weak. Therefore, the kinetic stress in dodgeball throwing could be dangerous for elbow injuries.

For young baseball player, there are several rules or regulation to prevent shoulder and elbow joint injuries. For example, The quantity of pitching is limited in one game, or the days for rest after games in a certain leagues or an association in Japan. However, for the dodgeball player, there is no any limitation at this stage (Wang et al., 2008). It's necessary for young dodgeball players to set a limit on the throwing number of times of ball throwing similar to young baseball players. In dodgeball games, there are several players with side hand arm motion with extended elbow. For young baseball players, curve pitches have been restricted because mechanical stress could be larger in curve throwing motion. It's also possible for dodgeball players that the kinetic stress is different in some different throwing style compared to classical overhand style. So, it's necessary to analyze other style throwing motion for the young dodgeball players.

CONCLUSION: The changing patterns of elbow joint torques in dodgeball throwing motion of children were similar to those for adult baseball pitchers. It is possible for young dodgeball players to suffer the acute and chronic injuries in elbow joint. For the healthy growth of children, it's necessary to set some rules or regulation to limit the number of times of throwing and to execute further biomechanical studies.

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Acknowledgement

This study was supported by the 2007 year grant in Aid for Scientific Research (C) 19500572 of Japan.