THE VARIATION OF DOMINANT ELBOW RANGE OF MOTION AMONG DIFFERENT MATURE STAGE FOR BASEBALL PITCHERS

Hsiao-Yun Chang[1], Shih-Chung Cheng[2], Chung-Nan Tsai[2], Chia-Lin Chen[3]

School of Physical Therapy, Chung Shan Medical University, Taichung, Taiwan[1]
Graduate Institute of Coaching Science, National Taiwan Sport University, Taoyuan, Taiwan[2]
Department of Physical Therapy, Tzu Hui Institute of Technology, Pingtung, Taiwan[3]

The purpose of this study was to examine the variation of elbow range of motion (ROM) in the dominant arm between different maturity levels in baseball pitchers. Sixty-two pitchers, including 17 early-puberty players, 22 later-puberty players, and 23 adult players, participated in this study. A goniometer was used to assess elbow ROM in the dominant arms, including elbow flexion, hyper-extension, supination, pronation and valgus angles. The results showed that smaller ROM was found in elbow flexion, supination, and pronation, and larger ROM in elbow valgue, in pithers of later puberty level ($p<.05$). In conclusion, changes in elbow ROM may develope with ages in baseball pitchers, the clinicans should pay attention to the change of elbow ROM in pitchers, especially in later puberty level.

KEY WORDS: bone mature, elbow joint, range of motion, throwing, baseball.

INTRODUCTION: Elbow injuries are commonly seen in baseball. Previous studies in the epidemiology of baseball injuries have reported the incidence of elbow injuries to be 20~26% in teenage pitchers (Lyman, Fleisig, Andrews, & Osinski, 2002; Chang, Chen, Jong, Lin, & Wang, 2007; Harada, Takahara, Mura, Sasaki, Ito, & Ogino, 2010). Recent studies have revealed that elbow injury in younger players is usually associated with risk factors, including overuse (Rizio & Uribe, 2001), muscle fatigue (Rizio & Uribe, 2001), insufficient muscle endurance (Shanley, Rauh, Michener, Ellenbecker, Garrison, & Thigpen, 2011), excessive number of pitching inning (Harad et al., 2010) and curve ball throwing (Olsen,Fleisig, Dun, Loftice, & Andrews, 2006; Nissen,Westwell, Ounpuu, Patel, Solomito, & Tate, 2009), which potentially influence elbow joint range of motion (ROM), raise the incidence of elbow injuries, and alter the throwing kinematic (Huang, Wu, Learman, & Tsai, 2010; Shanley et al., 2011). Therefore, evaluation of elbow ROM in youth baseball players could be crucial.

According to the biomechanical analysis of throwing, the wrist flexor-pronator and anconeus continue to contract during the arm acceleration and deceleration phases. The elbow has to withstand approximately 64N·m of valgus force in the late cocking phase. When the throwing movement reached the follow-through phase, the pronator electromyographic activity in pitchers who throw a curve ball is three times larger than that associated with a fast ball pitch (Sisto, Jobe, Moynes, & Antonelli, 1987; Werner, Fleisig, Dillman, & Andrews, 1993; Fleisig, Andrews, Dillman, & Escamilla, 1995; Escamilla, Fleisig, Barrentine, Andrews, & Moorman, 2002; Loftice, Fleisig, Zheng, & Andrews, 2004; Keeley, Hackett, Keirns, Sabick, & Torry, 2008). Every strong and repetitive throw results in high valgus loads which may cause changes in the elbow valgus carry angle or bone structure. A previous study indicated that around 12% pitchers in little league had slight restriction in elbow active extension, and a slight increase elbow valgus angle in the dominant arm (Gugenheim, Stanley,Wood, & Tullos, 1976). Chang, Chang, & Jong (2010) also found the adolescent baseball players showed significantly smaller elbow flexion, hyperextension, supination and pronation to supination total range in the dominant arm, and supination in the non-dominant arm than normal adults. In the same study, pitchers also demonstrated larger elbow valgus than fielders. Although the alteration of elbow ROM has been observed in each level of baseball pitchers, no study has been conducted to compare the difference in elbow ROM between

pitchers in different age level during growing. Therefore, the purpose of this study was to examine the variation of the elbow ROM in the dominant arm between different maturity levels in baseball pitchers.

METHODS: Sixty-two pitchers, including 17 early-puberty players (average age: 13.1 years), 22 later-puberty players (average age: 17.7 years), and 23 adult players (average age: 19.4years) participated in this study. All subjects, without a history of surgery in shoulder or elbow joint, presented no symptom of shoulder pain or elbow pain during the measurement period. A stainless steel goniometer (A Patterson medical products, Inc, Bolingbrook, IL) was used to assess elbow ROM, including elbow flexion, hyper-extension, supination, pronation and valgus angles in dominant arms.
When elbow flexion and hyper-extension measurements were performed actively, the subjects were sitting and the fulcrum of the goniometer was placed on lateral epicondyle of the humerus, parallel to the stationary arm, with the longitudinal axis of the line between the humerus and acromion process. The movable arm was parallel to the longitudinal axis of the line between the radius and radial styloid process. Elbow hyper-extension was measured starting from full elbow extension (0 degrees). A positive value indicated elbow hyper-extension. The terminal angle value was recorded. In contrast, a negative value indicated elbow flexion contracture. The terminal angle value was also recorded. Elbow flexion was measured from full elbow extension to full flexion and the terminal angle was recorded (Clarkson, 2000). Moreover, the flexion angle and the hyper-extension angle were summed to determine the flexion to hyper-extension total range of the elbow.
The elbow pronation and supination measurements were performed while subjects were sitting with the test elbow flexed at 90 degrees. The forearm was placed in mid-position, while a pen was fisted in the hand. The fulcrum of the goniometer was placed on the head of the third metacarpal and the movable arm was parallel to the pen and stationary arm were vertical in the ground. Forearm rotation caused the palm to facing the floor and the terminal angle was recorded as elbow pronation. Forearm rotation caused the palm facing the ceiling and the terminal angle was recorded as elbow supination (Clarkson, 2000). Moreover, the pronation and supination angles were summed to determine the pronation to supination total range of the elbow. The elbow valgus measurement was perform while subjects were sitting with arms fully extended, and palms facing the ceiling. The fulcrum of the goniometer placed on the mid-point of the elbow joint. The stationary arm was parallel to the centerline of the upper arm and the movable arm was parallel to the centerline of the forearm. The angle between the stationary arm and the movable arm was recorded (Clarkson, 2000).The test-retest reliability of the elbow ROM measurements has been previously performed (Chunang, Chang, Hshiao, Wu, Huang, et al., 2007; Chang et al., 2010). All measurements in this study were performed by a senior physical therapist (H.Y.C). One-way ANOVA and Post hoc comparison was used to compare the difference in elbow ROM between early-puberty, later-puberty, and adult pitchers.

RESULTS: The detail results were presented in Table 1. A significant decrease was found in elbow hyper-extension in later-puberty pitchers ($p<0.05$); The later-puberty pitchers demonstrated smaller elbow flexion than early-puberty and youth adults pitchers ($p<0.05$), respectively. A significant decrease in elbow valgus was found in adult pitchers than early puberty pitchers and later-puberty pitchers ($p<0.05$), respectively . No significant difference was found in elbow pronation between 3 maturity levels. The adult pitchers demonstrated larger elbow supination than later-puberty pitchers and early puberty pitchers ($p<0.05$), respectively. The smallest elbow flexion to hyper-extension total range was found in later-puberty level than adult pitchers and early puberty pithers ($p<0.05$), respectively. The smallest elbow pronation to supination total range was also found in later-puberty pitchers than early puberty pitchers and adult pitchers ($p<0.05$), respectively. The intra-class correlation coefficient (ICC) for elbow flexion angle measurement was 0.800, while the ICC for assessment of the hyper-extension angle was 0.655. The ICC values for assessment of the pronation and supination angles were 0.806 and 0.864, separately. The ICC value of assessment for elbow valgus angle was 0.661(Chunang, Chang, Hshiao, Wu, Huang, et al., 2007).

Table 1. The results of elbow range of motion for different maturity levels in baseball pitchers.

elbow range of motion	early puberty(1) (N=17)	later-puberty(2) (N=22)	youth adults(3) (N=23)	Post hoc results
Flexion, deg	141.5±8.1	132.6±3.0	139.5±5.5	2<3,1
Hyper-extension, deg	3.2±2.5	-2.3±6.9	3.1±6.9	2<3,1
Valgus, deg	12.1±2.3	13.0±4.1	7.7±5.5	3<1,2
Supination, deg	82.5±6.5	70.6±15.8	101.2±18.1	2<1<3
Pronation, deg	77.2±4.7	72.0±12.4	76.0±10.5	NS*
Flexion to hyper-extension total range, deg	144.6±8.3	130.3±7.4	142.6±9.3	2<3,1
Pronation to supination total range, deg	159.8±9.5	142.0±20.3	177.2±20.8	2<1<3

*NS: no significant among three maturity level.

DISCUSSION: The results showed that pitchers in later puberty level had smaller elbow flexion, supination, and pronation; on the pther hand, pitchers in later puberty level demonstrated larger elbow valgue among 3 maturity stages. Previous studies have also found alterations in elbow ROM in the dominant arm in professional pitchers (Reinold, Wilk, Macrina, Sheheane, Dun, & Fleisig, 2008). Moreover, Wright, Steger-May, Wasserlauf, O'Neal, Weinberg et al. (2006) reported differences in elbow extension, flexion and total arc of flexion-extension between the dominant and non-dominant arms. However, these researchers reported that the differences were not associated with age, duration of pitching or elbow surgery (Wright et al., 2006). Reinold et al. (2008) reported that force eccentric contraction of the biceps in the throwing arm would result in a reduction in elbow flexion, and last for 24 hours. This may explain the adaption of the bone and soft tissues around the elbow.

The pitchers in later puberty level demonstrated smallest variations in all elbow ROM among three maturity stages. We presumed that early puberty pitchers have less throwing experience which has not resulted in a significant change in elbow ROM. However, when the players grow up to later puberty level, the playing experience reached to 8-10 years, with which repeated throwing may result in alternations in elbow ROM. Beacuse of the restriction in elbow ROM, some pitchers may sustain elbow injuries and subsequently left baseball, only healthy pitchers survive and reach adult level. The evidence of the incidence of elbow injuries has been provided. Previous study found a incidence of 6.7% in elbow injuries in pitchers of 9 to 14-years old (Lyman et al., 2002), and the incidence raised to 18.9% in high school pitchers (Collins & Comstock, 2008), but decreased to 7.1-7.8% in collegiate level (Dick, Sauers, Agel, Keuter,Marshall, McCarty, et al., 2007). Comparing with the tendency of incidence of elbow injuries, the changes of elbow ROM developes slower.

In this study, the intra-tester reliabilities of elbow ROM measurements were moderate to high, especially in elbow valgus angle. It may resulted from no bony landmark to map the when researcher measured. It would be affecting our results of the study. In order to increase reliability of elbow ROM measurement in future studies, we suggest that it may be better to use radiographic methods for elbow ROM assessments rather than goniometry.

CONCLUSION: The pitchers in lateral puberty level demonstrated smaller elbow flexion, supination and pronation, but larger elbow valgue, among 3 maturity stages. The results have warranted further managements for the biceps and flexor-pronator muscles in throwing arm in order to maintain elbow ROM and prevent from injuries in later puberty level.

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