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ORIGINAL ARTICLE

The effect of repetitive baseball pitching on medial elbow joint space gapping associated with 2 elbow valgus stressors in high school baseball players

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Background: To prevent elbow injury in baseball players, various methods have been used to measure medial elbow joint stability with valgus stress. However, no studies have investigated higher levels of elbow valgus stress. This study investigated medial elbow joint space gapping measured ultrasonically resulting from a 30 N valgus stress vs. gravitational valgus stress after a repetitive throwing task.

Methods: The study included 25 high school baseball players. Each subject pitched 100 times. The ulnohumeral joint space was measured ultrasonographically, before pitching and after each successive block of 20 pitches, with gravity stress or 30 N valgus stress. Two-way repeated measures analysis of variance and Pearson correlation coefficient analysis were used.

Results: The 30 N valgus stress produced significantly greater ulnohumeral joint space gapping than gravity stress before pitching and at each successive 20-pitch block ($P < .01$). For the 2 stress methods, ulnohumeral joint space gapping increased significantly from baseline after 60 pitches ($P < .01$). Strong significant correlations were found between the 2 methods for measurement of medial elbow joint space gapping ($r = 0.727$ – 0.859 , $P < .01$).

Conclusions: Gravity stress and 30 N valgus stress may produce different effects with respect to medial elbow joint space gapping before pitching; however, 30 N valgus stress appears to induce greater mechanical stress, which may be preferable when assessing joint instability but also has the potential to be more aggressive. The present results may indicate that constraining factors to medial elbow joint valgus stress matched typical viscoelastic properties of cyclic creep.

Level of evidence: Basic Science Study; Kinesiology

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Keywords: Elbow; baseball; ultrasound; medial elbow joint space gapping; repetitive pitching; valgus stress

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Saitama Medical University Ethics Committee (M-66), Saitama, Japan.

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Baseball players risk medial elbow injury from extreme valgus stress generated across the elbow joint as a result of repetitive throwing.^{9,13,14,33} Injury occurs from valgus stress inducing large tensile stress on medial elbow soft tissues.¹⁴ Previous studies have demonstrated asymmetry and long-standing changes in medial elbow joint space gapping in baseball pitchers.^{7,8,12,17,28,30,31} A previous study of high school baseball players found that pitching more than 60 times in a session caused increased medial elbow joint space gapping, with a consequent increased burden on the medial elbow joint and associated tissues.²⁰ This study identified that medial elbow joint space gapping is increased with repetitive throwing, but more detailed information is required.

Quantitative methods of assessment of medial elbow joint space gapping include the valgus stress test using a Telos device (Telos GA-II-E stress device; Telos, Weiterstadt, Germany) and the gravitational effect of forearm weight inducing valgus stress at the elbow.^{7,8,12,17,19,20,28,30,31} The Telos device has been widely used as a quantitative tool to assess medial elbow joint space gapping in baseball players, possibly due to the uniform condition in which elbow valgus stress can be applied.^{7,8,12,31} Gravitational stress has the advantage of being able to induce joint space gapping without special equipment, again with uniform force, which has been widely used as a quantitative tool to assess medial elbow joint space gapping in baseball players.^{17,19,20,30} Harada et al¹⁷ reported that gravitational stress and the Telos device both seem useful for the assessment of medial elbow joint space gapping, but no studies have investigated whether a stronger valgus stress would provide better data than simple gravity.

We hypothesized that applying maximum valgus stress to gap the medial elbow joint would result in more accurate data on medial elbow joint space gapping. Although the Telos device and gravity stress have been mainly used as measurement methods of medial elbow joint space gapping, no report has quantitatively investigated nearly maximum valgus stress on medial elbow joint space gapping.

The purpose of this study was to investigate the effect of a repetitive baseball pitching task on medial elbow joint space gapping and the viscoelastic properties of medial elbow joint structures induced by 30 N valgus stress or gravity valgus stress. If more accurate data can be obtained by applying a 30 N valgus stress, it can be used as a reliable measurement method of medial elbow joint space gapping and potential medial elbow laxity. This may help develop a better understanding of how to prevent elbow injury in baseball pitchers.

Materials and methods

Participants

The study included 25 healthy high school baseball players (mean \pm standard deviation: age, 16.6 \pm 0.7 years; height, 172.6 \pm 6.3 cm; weight, 66.1 \pm 7.1 kg; years of baseball experience, 8.8 \pm 1.9 years) who volunteered to participate. Participants were excluded from the study if they had (1) pain during throwing

action, (2) a history of orthopedic shoulder, elbow, or hand surgery, or (3) pitched in the 24 hours before measurement. All participants agreed to sign an informed consent declaration.

Setup and protocol

The throwing protocol was reported in a previous study.²⁰ Measurement commenced after the participants performed a preparation routine of stretching and warm-up throwing. The pitching protocol consisted of 100 fastball pitches (20 sets of 5 pitches at ball intervals of 15 seconds at maximum effort) from the set position toward the simulated strike zone. The official baseball (MIZUNO Co., Ltd., Osaka, Japan), which weighed 141.7 to 148.8 g, was used during the pitching protocol. We calculated the average ball velocity for the first 20 pitches, and subsequent throws that were 70% less than this value were not included.

Measurements

The ulnohumeral joint space was measured with ultrasonography (Aloka Co., Ltd., Tokyo, Japan) before pitching and after every 20 pitches with the application of 2 different elbow valgus stresses: under gravity stress or 30 N valgus stress. Ultrasound imaging of the medial aspect of the throwing elbow was performed with the use of a 10-MHz annular array transducer. Grip strength was also measured before pitching and after 100 pitches.

Gravity stress was applied to the forearm to strain the medial aspect of the elbow and to assess medial elbow joint space gapping. Gravity stress used in this study has been reported as being useful in the assessment of medial elbow joint space gapping and is similar to measurements obtained with the commonly used Telos device.¹⁷ Participants were placed supine on the bed with the shoulder in 90° abduction and 0° horizontal abduction, the elbow in 90° flexion, and the forearm in neutral position. The elbow joint lay off the edge of the bed.^{17,19,20,27,30} A towel roll and a digital inclinometer were used to maintain the humerus in the horizontal plane (Fig. 1, A).

Thirty N valgus stress was applied to the ulnar styloid process at the wrist to strain the medial aspect of the elbow and to assess medial elbow joint space gapping. Thirty N valgus stress was applied by a separate independent examiner using a dynamometer (3050 Aikoh Engineering Co., Ltd., Higashi, Osaka, Japan). Participants were placed supine on the bed with the shoulder in 90° abduction, 0° horizontal abduction, with the elbow in 30° flexion, and the forearm in supinated position. Elbow flexion was set to 30° to ensure that external rotation of the shoulder joint did not occur when valgus stress was applied to the elbow joint. The elbow joint lay off the edge of the bed. A towel roll and a digital inclinometer were used to maintain the humerus in the horizontal plane (Fig. 1, B).

No participant experienced elbow pain during the examination. The total time required for all measurements was less than 5 minutes. The ultrasound transducer was placed on the medial aspect of the elbow in such a position that the ultrasound imaging included the top of the medial epicondyle of humerus and the medial tubercular portion of the ulnar coronoid process.²⁰ The degree of medial elbow joint space gapping was assessed by measuring the ulnohumeral joint space between the distal-medial corner of the trochlea of humerus and the proximal edge of the medial tubercular portion of the ulnar coronoid process. The distance of the 2 points (the distal-medial corner of the trochlea of humerus and the proximal edge of the medial tubercular portion of the coronoid process of ulnar) on the image was

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