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ORIGINAL ARTICLE

Left-handed skeletally mature baseball players have smaller humeral retroversion in the throwing arm than right-handed players

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Background: It is known that the humeral retroversion of baseball players is greater in the throwing arm than in the nonthrowing arm. An investigation measuring dry bone specimens also showed that the right humerus had greater retroversion than the left. Considering these facts, it was hypothesized that humeral retroversion would differ between right- and left-handed players. This study aimed to compare the bilateral humeral retroversion between right- and left-handed skeletally mature baseball players.

Methods: We investigated 260 (196 right-handed and 64 left-handed) male baseball players who belonged to a college or amateur team. Bilateral humeral retroversion was assessed using an ultrasound-assisted technique (humeral torsion angle [HTA]) as described by previous studies. Analysis of covariance, adjusted for handedness and baseball position, assessed the effect of throwing arm dominance on HTA.

Results: In comparison of the throwing arm, HTA was significantly smaller in left-handed (left humerus) than in right-handed (right humerus) players (77° vs. 81°; $P < .001$). In comparison of the nonthrowing arm, HTA was significantly greater in left-handed (right humerus) than in right-handed (left humerus) players (73° vs. 69°; $P < .001$). The mean side-to-side difference of HTA was significantly smaller in left-handed than in right-handed players (3° vs. 12°; $P < .001$).

Conclusions: Humeral retroversion of left-handed skeletally mature baseball players was significantly smaller in the throwing arm, greater in the nonthrowing arm, and smaller in side-to-side differences than that of right-handed players. These findings may be key to understanding some of the biomechanical differences between right- and left-handed baseball players.

The Nagoya City University Graduate School of Medical Sciences Ethics Committee approved the protocol of this study (764). Informed consent was obtained from all individual participants.

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It is known that the humeral retroversion of baseball players is greater in the throwing arm than in the nonthrowing arm.[2,10,13,18] It is reported that the mean humeral retroversion is 78° in the fetus,[3] 65° in children aged 4 months to 4 years, 38° in those aged 10-12 years,[4] and 30° in adults.[7] This physiologic derotation process of the humeral head during growth is assumed to be restricted by repetitive throwing, specifically in the throwing arm.[8,20] This theory is supported by the biomechanical analysis of the baseball pitching motion, which showed that numerous rotational torques were generated in the throwing shoulder near the time of maximum external rotation in the cocking phase.[5,14]

On the other hand, Edelson measured humeral retroversion of dry bone specimens and reported that humeral retroversion was greater in the right arm than in the left arm regardless of gender and race.[3] In the study, there was no information about handedness of subjects, which would affect the side-to-side differences of humeral retroversion.[7] Taking these facts into consideration, humeral retroversion might differ between right- and left-handed skeletally mature baseball players. If the difference of humeral retroversion exists, it may help explain some of the biomechanical differences between right- and left-handed baseball players that have been reported.[15,17]

The purpose of this study was therefore to compare the bilateral humeral retroversion between right- and left-handed skeletally mature baseball players. It was hypothesized that humeral retroversion of left-handed players would be significantly smaller in the throwing arm, greater in the nonthrowing arm, and smaller in side-to-side differences than that of right-handed players.

Materials and methods

This study was performed as a part of a medical checkup. In this study, 266 male baseball players who belonged to a college team or an amateur team were enrolled.

Bilateral humeral retroversion was assessed by humeral torsion angle (HTA) as described and validated by Myers et al.[9] Subjects lay supine on a treatment table with 90° of shoulder abduction and 90° of elbow flexion. An 18 MHz linear array ultrasound transducer (MyLab 25; Esaote, Genoa, Italy) was placed on the anterior aspect of the subject's shoulder with the ultrasound transducer level with the plane of the treatment table (verified with a bubble level) and aligned perpendicular to the long axis of the humerus in the frontal plane (Fig. 1, *A*). HTA measurement was done at the proximal end of the bicipital groove. The subject's humerus was passively rotated so that the line passing the apexes of the greater and lesser tuberosities would be horizontal on the screen (Fig. 1, *B*). A digital inclinometer was then placed on the ulna and recorded the forearm

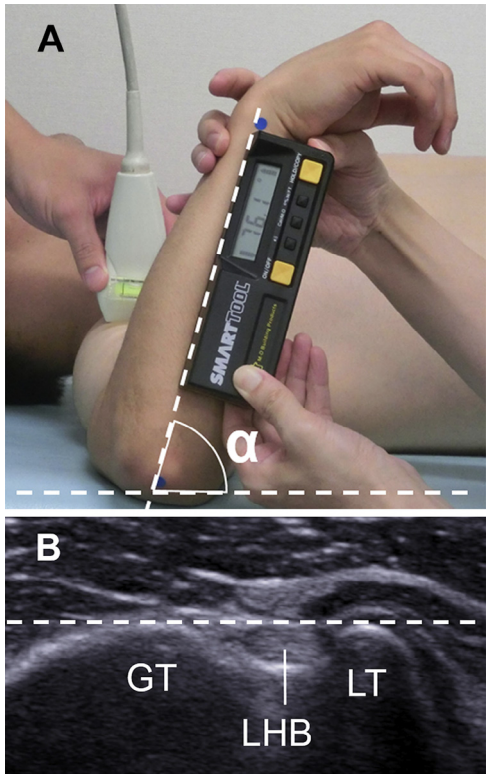

Figure 1 Assessment of humeral torsion angle (HTA). (**A**) Subjects lay supine with 90° of shoulder abduction and 90° of elbow flexion. A linear array ultrasound transducer was placed on the anterior aspect of the subject's shoulder. A digital inclinometer was placed on the ulna and recorded the forearm inclination angle with respect to the horizontal line (this angle α represented HTA). ●, Olecranon and distal end of ulna. (**B**) Echogram used for HTA measurement. The subject's humerus was passively rotated so that the line passing the apexes of the greater and lesser tuberosities would be horizontal on the screen. *GT*, greater tuberosity; *LT*, lesser tuberosity; *LHB*, long head of biceps.

inclination angle with respect to the horizontal line (Fig. 1, *A*). This forearm inclination angle with respect to the horizontal line represented HTA.[9] Although this ultrasound-assisted technique was an indirect measurement of humeral retroversion, a strong positive correlation was reported between the HTA obtained using ultrasound and humeral retroversion obtained using computed tomography.[9] Therefore, this ultrasound-assisted technique was used in many baseball research studies.[8,9,16,18,20]

Measurements were done by 2 primary examiners: 1 performed the ultrasound scan and the other adjusted the rotation of humerus and measured HTA using a digital inclinometer. Intra-rater and inter-rater reliabilities for HTA measurement were assessed using 30 healthy shoulders. Intra-rater reliability was assessed for primary examiners using a single measurement of HTA on 2 sep-