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ORIGINAL ARTICLE

Effects of glenohumeral internal rotation deficit on baseball pitching among pitchers of different ages

Paul Pei-Hsi Chou, MD, PhD[a,b], You-Li Chou, PhD[c], Yan-Sheng Wang, MS[d], Rong-Tyai Wang, PhD[d], Hwai-Ting Lin, PhD[a,e,*]

[a]*Department of Sports Medicine, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan*
[b]*Division of Sports Medicine, Department of Orthopedic Surgery, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan*
[c]*Institute of Biomedical Engineering, National Cheng-Kung University, Tainan, Taiwan*
[d]*Department of Engineering Science, National Cheng-Kung University, Tainan, Taiwan*
[e]*Department of Medical Research, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan*

Background: Previous studies have reported that glenohumeral internal rotation deficit (GIRD) may increase the risk of shoulder injury. However, the effects of GIRD on baseball pitching among pitchers of different age groups are still unclear.

Methods: The study participants were 24 high school and 24 university pitchers. For each age group, the pitchers were evenly divided into a GIRD group and a normal group. The pitching motion of each participant was captured using a motion analysis system at a sampling frequency of 300 Hz. The kinematics and kinetics of the throwing shoulder and trunk were quantified, and statistical differences between the groups were examined by 2-sample *t* tests.

Results: For both age groups, significant differences were observed in shoulder external rotations of the GIRD and normal groups. Compared with the university pitchers in the normal group, the university pitchers with GIRD exhibited a greater shoulder loading and did more internal rotation work in the acceleration phase. The high school pitchers with GIRD showed a larger trunk tilt and less trunk rotation than the university pitchers with GIRD. However, the university pitchers with GIRD exhibited a larger shoulder posterior force and horizontal adduction torque than the high school pitchers with GIRD.

Conclusion: Pitchers with GIRD do change their pitching motions, and the greater resulting shoulder joint loading predisposes them to a greater risk of shoulder injury, especially among university pitchers.

Level of evidence: Basic Science Study; Kinesiology

Keywords: athletic performance; arm injury; age groups; shoulder; pitching mechanism; range of motion

Competitive overhead throwing generates a large load on the dominant shoulder. In baseball pitching, for example, the humeral angular velocity can reach 7250°/s, and the internal rotation (IR) torque may be as much as 90 N-m.[7,10,23] Over time, these repetitive torques and velocities cause adaptive change in the soft tissue and bony architecture of the

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*Reprint request: Hwai-Ting Lin, PhD, Department of Sports Medicine, Kaohsiung Medical University, 100 Shih-Chuan 1st Rd, Kaohsiung 80708, Taiwan.

E-mail address: whiting@kmu.edu.tw (H.-T. Lin).

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shoulder joint. This change leads in turn to a higher external rotation (ER) and lower IR of the shoulder.[2,17] The disparity between the IR of the dominant and nondominant shoulders has attracted significant attention in clinical research and has led to the use of the term "glenohumeral internal rotation deficit" (GIRD) to describe cases in which the throwing shoulder exhibits a loss of 20° or more in IR compared with the nonthrowing shoulder.[2]

Previous studies have reported a possible association between changes in the glenohumeral IR and the risk of shoulder and elbow injury among baseball pitchers.[5,11,14] Moreover, research has shown that humeral retrotorsion and increased tightness of the posterior capsule are both potential causes of range of motion (ROM) deficits of the dominant vs. the nondominant throwing shoulder.[12,16,18] Moreover, GIRD and humeral retrotorsion have been found to increase with age in youth/adolescent baseball players.[12] Only 1 study, however, has shown significant differences in the pitching motions of Little League pitchers with GIRD, with those pitchers only having been found to exhibit a larger ER of the shoulder at the end of the arm cocking phase than non-GIRD pitchers.[15]

In a study of 231 healthy male pitchers with various levels of development, Fleisig et al[9] found that while the pitching mechanics did not change significantly with differing levels of development, the greater force and torque generated by adult pitchers increased their risk of throwing injuries. Meanwhile, another study found that the maximum ER of the throwing shoulder during the arm cocking phase of the pitching cycle may decrease with age.[6] That said, the literature still lacks detailed information regarding the effects of GIRD on the pitching motions of baseball pitchers of different ages. Thus, the present study investigated the differences in the kinematic and kinetic parameters of GIRD and non-GIRD pitchers of high school and university age in Taiwan.

Materials and methods

This study was a controlled laboratory study conducted to investigate the kinematic and kinetic differences among healthy pitchers and pitchers with GIRD.

The study participants were 48 male baseball pitchers: 24 pitchers from Taiwanese high school competitive baseball teams and 24 pitchers from Taiwanese university competitive baseball teams. In each age group (ie, high school and university), 12 of the pitchers exhibited GIRD and were thus denoted as the GIRD group, and the same number of pitchers in each group did not and were thus denoted as the normal group.

The existence of GIRD was determined from ROM measurements of the shoulder, with GIRD being defined as the throwing shoulder exhibiting a loss of 20° or more in IR.[2] In addition to being a pitcher of high school or college age, the inclusion criteria included no history of injury to the shoulder joint or elbow joint of the throwing arm for at least 6 months before the study. The exclusion criteria, meanwhile, included any past shoulder surgery. All of the pitchers who ultimately participated in the study were right-arm dominant and had overhead throwing ability. The anthropometric data of all the pitchers are reported in Table I.

Firstly, the participants and their parents read and signed an informed consent form approved by the Institutional Review Board of the affiliated high school or university. Then, the physical status, pitching career, and ER and IR measurements of the dominant and nondominant shoulders at 90° of abduction were obtained for each participant. The ER and IR measurements were acquired with a long-arm goniometer[19] by a physical therapist experienced in the treatment of throwing athletes and blinded with respect to the given participant's dominant arm. To avoid the influence of scapular movement

Table I The anthropometric data and passive range of motion shoulder joints in glenohumeral internal rotation deficit and normal pitchers

Variable	High school pitchers			University pitchers		
	GIRD	Normal	*P* value	GIRD	Normal	*P* value
Age, y	16.5 ± 1.0	15.8 ± 0.8		20.7 ± 1.5	19.8 ± 0.8	
Height, cm	176.7 ± 4.4	175.0 ± 4.9		180.7 ± 6.2	178.2 ± 4.4	
Weight, kg	74.6 ± 10.6	71.4 ± 11.0		81.9 ± 10.2	74.8 ± 7.9	
Internal rotation, °						
Dominant	41 ± 9	56 ± 12	**.007**	39 ± 10	32 ± 3	.077
Nondominant	67 ± 12	65 ± 11	.395	59 ± 14	40 ± 3	.072
External rotation, °						
Dominant	136 ± 10	139 ± 9	.287	140 ± 10	135 ± 2	.124
Nondominant	123 ± 10	115 ± 13	.087	119 ± 14	118 ± 5	.417
Total arc of motion, °						
Dominant	177 ± 16	195 ± 20	**.033**	179 ± 18	166 ± 3	.072
Nondominant	190 ± 15	180 ± 23	.148	178 ± 25	158 ± 7	**.049**
*Internal rotation deficit of dominant, °	26 ± 6	9 ± 5	**<.001**	20 ± 6	8 ± 3	**<.001**

Values are expressed as mean ± standard deviation. Bold values indicate statistical significance ($P < .05$).
GIRD, glenohumeral internal rotation deficit.
* Significance difference ($P < .05$) between the groups.