ISOKINETIC EVALUATION OF SHOULDER INTERNAL AND EXTERNAL ROTATORS STRENGTH AND ENDURANCE IN FOUR LEVELS OF SCHOOL-AGED BASEBALL PLAYERS

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The purpose of this study was to compare strength and endurance differences in shoulder external and internal rotation torque ratios among four levels of school-aged baseball players. The subjects (N=97) were assessed the strength and endurance strength of shoulder internal and external rotation muscles with Kin Com dynamometer. The functional scapular plane of shoulder movement was used as the testing position. Strength development of IR and ER generally varied with school-aged increased. Comparing with adult pitchers, adolescence and pre-adolescence baseball pitchers had relatively weak shoulder external rotation muscles, especially after high repetition muscle contraction. In order to prevent shoulder injury in adolescence and pre-adolescence baseball throwers, muscle endurance in shoulder external rotators must be emphasized.

KEY WORDS: shoulder, rotation strength, baseball pitcher.

INTRODUCTION: Shoulder throwing injuries in children and adolescent baseball players are serious problem in sports medicine (Kannus, P., Nittimaki, S., & Jarvinen, M.,1988). The throwing motion is divided into windup, early cocking, late cocking, acceleration, deceleration and follow-through phases (Wasserlauf, B.L. & Paletta, G.A., 2003). The greatest stresses on the throwing arm are during late cocking, acceleration, deceleration, and follow-through. The posterior rotator cuff and periscapular muscles are eccentrically active to control arm deceleration. Additionally, the rotator cuff dynamically stabilize the humeral head in the glenoid fossa and provide the main deceleration forces to the pitching arm during the follow-through phase of pitching (Donatelli, R et al, 2000). Thus, sufficient shoulder external rotation strength and the balance between shoulder external rotation (ER) and internal rotation (IR) strength are believed to be important in the prevention of shoulder throwing injures. Many researches had investigated the ratio of external-to-internal for strength (ER/IR ratio) in an attempt to identify imbalances that may lead to injury, but the strength development in shoulder rotator muscles is not well understood. Therefore, the primary purpose of this study was to compare strength and endurance differences in shoulder external and internal rotation torque ratios among four levels of school-aged baseball players.

METHOD: Ninety-seven baseball players voluntarily participated in this study. Based on their age, subjects were categorized into four groups: college baseball players (19-24 years), high school baseball players (16-18 years), junior high school players (13-15 years), and little league baseball players (9-12 years). This study included two sessions: maximum torque assessment and endurance assessment. The apparatus of both sessions is the Kin Com125 AP (Chaganotta, TN). The scapular plane was used as reference plane of shoulder internal and external rotation. In order to archive scapular plane movement during shoulder internal and external rotation, each subject's shoulder was positioned in 450 abduction and at 300 anterior to the frontal plane. The elbow was flexed to 900 with the forearm and wrist in the neutral position. Eternal rotation was completed from 400 internal rotation to 600 external rotation; internal rotation was completed from 600 external rotation to 400 internal rotation.

In the maximum torque assessment session, each subject was requested to perform five maximally concentric contractions in direction of shoulder internal and external rotation at velocity of 90 deg/sec with the dominant arm. The middle three of the five trials were averaged for analysis.

In the endurance assessment session, the testing position and speed were the same as above but the number of trials was thirty. To assess the shoulder internal and external rotation endurance, the average of the last five repetitions was used to represent endurance torque and

for analysis. In order to understand behavior of strength loss in endurance test, percentage of strength loss was used in this study. The percent of strength loss was defined as

$$\% \text{ of strength loss} = [1-(T_{final}/T_{initial})] \times 100\%$$

in which $T_{initial}$ is the average torque of the first five repetitions and T_{finial} is the average torque of the last five repetitions in the endurance test.

Analysis Methods: The parameters of maximum strength torque, endurance torque and IR-to-ER ratio were analyzed for the all subjects in each age-leveled group. A 2 (rotation direction) x 4 (age levels) ANOVA was applied with statistical significance set at the $p<.01$ level. Post-Hoc testing was performed when main effect differences were identified with significant level set at $p<.01$. One-way ANOVA associated with Scheffe's multiple comparisons was used to identify the difference of ER-to-IR ratio among the four tested groups.

RESULTS AND DISCUSSION: At strength assessment, the ANOVA results of shoulder rotation strength showed that internal rotator torque was significantly greater than external rotator torque among four school-aged players as evident by ratios less than 1.0 (Table 1). The order of internal and external muscle strength from high to low was college, high school, junior high school and primary school-aged players. The difference of muscle size can explain this result. Since the larger latissimus dorsi and pectoralis major muscles are the most responsible muscles for shoulder internal rotation, the shoulder internal rotation muscles generate greater torque than external rotation muscles.
Shoulder external/internal rotation torque ratios are also present in Table 1 and the order from low to high is college, high school, junior high school and primary school-aged players. Although ratio appeared tendency among four test groups, the difference did not reach significant level ($p>.05$). Muscle maturity status of shoulder rotators in adult is different with adolescent and pre-adolescent baseball players. In college and high school baseball players, the shoulder internal rotation muscles become mature. Thus, in adult players, shoulder internal rotation torque can be increased with muscle mass and, therefore, their external/internal rotation torque ratios become low. However, in junior high and primary school players, shoulder internal rotation muscle are not fully developed. Their shoulder internal rotation torque can not generate large enough torque. So, their shoulder external/internal rotation torque ratios are high.

Table 1 Strength results of shoulder external and internal torque among four school-aged baseball pitchers.

	Group			
Direction	College player (n=19)	High school player (n=24)	Junior high school player (n=29)	Primary school player (n=25)
IR (N.m)	51.38 ± 8.94^{A}	41.48 ± 9.30^{B}	23.79 ± 7.79^{C}	14.84 ± 4.01^{D}
ER (N.m)	38.43 ± 8.37^{A}	33.74 ± 9.31^{A}	19.29 ± 6.98^{B}	13.00 ± 4.13^{C}
ER/IR ratio	0.69 ± 0.08	0.73 ± 0.11	0.76 ± 0.13	0.77 ± 0.12

a Means with the same upper case letter are not significantly different ($p > .05$).
b Means with different upper case letter are significantly different ($p > .05$).

At endurance assessment, both shoulder internal and external rotator muscles showed their endurances from high to low were college, high school, junior high and primary school-aged players (Table 2). Like the strength performance, the endurance showed internal rotator endurance was greater than external rotator endurance in all test groups. Local muscle fatigue makes ER-to-IR torque ratios in four levels of school-aged baseball throwers appear different alternation behaviors. Comparing with college and high school-aged players, junior high school and primary school-aged players showed more strength loss in external rotator muscles than in internal rotator muscles. These data provided evidence in explanation of alternation in ER/IR

endurance ratio. In college and high school players, shoulder external/internal rotation torque ratio changed from low to high. This was due to more prone to loss their internal rotators' strength as evidence of increasing their percentage of strength loss. In junior high and little league baseball players, shoulder external/internal rotation torque ratio changed from high to low. This was due to more prone to loss their external rotators' strength as evidence of increasing their percentage of strength loss.

Table 2 Endurance results of shoulder external and internal torque among four school-aged baseball pitchers.

	Group			
Direction	College player (n=12)	High school player (n=15)	Junior high school player (n=27)	Primary school player (n=18)
IR				
Strength (N.m)	18.48±2.89^{A}	15.20±3.45^{B}	7.58±4.73^{C}	4.44±2.31^{D}
% of strength loss	66.8±22.1	64.2±20.2	68.2±32 %	71.2±29 %
ER				
Strength (N.m)	17.51±4.56^{A}	11.45±1.78^{B}	4.59±2.91^{C}	3.18±1.89^{C}
% of strength loss	49.2±19.1%^{A}	62.2±17.2%^{B}	73.8±9.5 %^{C}	73.2±7.2 %^{C}
ER/IR ratio	0.95±0.16^{A}	0.76±0.12^{A}	0.63±0.21^{B}	0.75±0.24^{AC}

CONCLUSION: In our study, we found that the strength development between shoulder internal and external rotators was significantly different among four levels of school-aged baseball players and that glenohumeral external rotator muscles in young pitchers were more prone to lose its strength than in adult pitchers. Clinical implication of these findings is that young baseball athletes could be more prone to suffer shoulder overuse injury than adult players especially after high repetition of shoulder muscles contraction because they are more prone to lose their protection strength of external rotators in follow-through phase. Coach and trainer must note the problem of overuse injury in primary and junior high school-aged baseball players. Intensive-training schedule designed for adult baseball players should not be appropriate for junior high and primary school baseball players. In order to prevent junior high school and primary school athletes suffering shoulder overuse injury, they should emphasize in development of adequate endurance on shoulder external rotation muscles.

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