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Shoulder Strength Ratio Between Baseball Players and General Population

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Abstract: The purpose of this study was to confirm the imbalance of bilateral rotator cuff strength in baseball players and to compare the differences with general public. This study was a cross sectional analysis of 92 subjects. Three groups of 62 male baseball players and 30 general public were studied. External rotator muscle strength of the rotator cuff was bilaterally measured with a hand-held dynamometer. Measured value was converted to Shoulder Strength Ratio (SSR) and analyzed with in-group, between-group. Statistical analysis was performed using independent t-test and ANOVA. Post hoc test of Scheffe was proceeded. Mean value of SSR for each player group was 0.94 in middle school players, 0.98 in high school players, 0.9 in adult players. SSR were lowest at adult baseball players, however, there was no significant difference in any baseball player groups. Mean value of shoulder external rotation strength ratio was 0.94 for baseball player group and 1.02 for general public group. Baseball player group of mean SST was lower than general public group. Unlike previous study with professional baseball player, adolescent baseball player's dominant shoulder of external rotator muscle strength was not significantly weaker than non-dominant shoulder. However, there was significant difference between player and non-player groups. In this study, the external rotator strength ratio of baseball players showed significantly lower than general public group. Among baseball player, adult player group showed the greatest difference in bilateral external rotation strength.

Key words: Shoulder ratio, rotator cuff strength, external rotator strength, baseball injury, handed dynamometer, group

INTRODUCTION

Baseball was a typical overhead-throwing sport. The process of throwing the ball was divided into several phase from wind-up to follow-though. The high torque values on shoulder that occurred immediately after the athletes throw the ball were mainly generated from the trunk and shoulder in the acceleration phase and this force transmitted to the ball of the finger tip. After throwing the ball, a 400 N of posterior shoulder musculature, a glenohumeral compression force of 1090 N and a horizontal abduction of 97 Nm were generated on the shoulder joint (Fleisig *et al*., 1995). Therefore, various muscles including the rotator cuff muscle contributes to stabilizing the glenohumeral joint while overhead throwing motion. This overloading torque on shoulder caused many baseball players to suffer a shoulder injury and to spend a lot of time and money to recover. Furthermore, the weakening of the external rotator muscles could increase the injury rate (Byram *et al*., 2010).

In order to reduce the load on the shoulder that occurred during the pitching, the enough external rotation strength corresponding to the strong internal rotation strength was required. Relatively, the internal rotator strength improved more than external rotator due to the internal rotation of the throwing mechanism and relatively large size of the internal rotator muscles such as latissimus dorsi and pectoralis major muscle. However, since the external rotation muscle was not so an unbalance occurred between the two muscles and soft tissue injury occurred more often (Trakis *et al*., 2008; Byram *et al*., 2010). Therefore, additional external rotator exercises should be performed for baseball players.

Previous studies reported significant asymmetry of the rotator cuff muscles on baseball players. Wilk studied 150 professional baseball pitchers bilateral shoulder. External rotator strength was measured with Biodex isokinetic dynamometer at the 180 deg/sec and there was a significant statistical difference for the external rotators which of dominant shoulder was weaker (Wilk *et al*., 1993). Also, 26 high school baseball player's rotator cuff strength of peak torque, peak torque to body weight ratio internal-external ratio was measured with Cybex 2. The result showed, 90 and 240 deg/sec of measure, external/internal ratio and peak torque was significantly lower in pitching shoulder than on the non-pitching side (Hinton, 1988).

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However, there were many opposite results. Trakis *et al.* (2008) studied in high school baseball player, dominant shoulders external rotation strength was stronger than non-dominant shoulder. Donatelli *et al.* (2000) studied 125 professional baseball players dominant and non-dominant shoulder of internal, external rotational strength with isokinetic machine. There was no significant different in peak torque of external rotators but internal rotation was significantly ($p<0.001$) greater on dominant arm. Perrin *et al.* (1987) also measured bilateral internal external strength of college baseball players and general person with a Cybex 2 isokinetic Dynamometer. There was no significant difference with bilateral shoulder in both groups.

Hinton (1988) mentioned that the strength of the rotator cuff muscles was related to the baseball career and the age of the player (Donatelli *et al.*, 2000). However, there was a lack of comparative studies with other players at different levels and even the results of research on baseball player's rotator cuff strength differed a lot. Therefore, the purpose of this study was to compare the difference in rotator cuff strength of both shoulders in all groups and to confirm the difference of the rotator cuff strength ratio between baseball players and the general persons.

MATERIALS AND METHODS

Subjects: A total of 95 subjects participated in this study, those who included in following criteria was excluded; the participant feels that shoulder pain affects performance or mechanics in any game, whether the participant sustain any discomfort on shoulder during the test and if the participant sustains any injuries that required medical treatment on shoulder. Between the ages of 13 and 15 are middle school group, 16 and 18 are high school, over the age of 19 were classified as adult groups.

Strength measurements: Using the handheld dynamometer (Lafayette Manual Muscle Tester) was used to record quantitative strength measurement in pounds. Intra-rater validity and reliability of measuring external rotator muscle with hand-held dynamometer was already established in the literature (Byl *et al.*, 1988; Sullivan *et al.*, 1988). Data were gathered on the dominant and non-dominant shoulder. External rotator muscle strength was measured with participants were seated with the elbow flexed to 90° and the shoulder flexed 15° (Reinold *et al.*, 2004). The dynamometer placed on the dorsal aspect of the wrist and the peak torque of three repetitions was recorded. For each test, the average value of the 3 trials was calculated with each shoulder (Fig. 1).

Fig. 1: External rotation measurement

To compare external rotator strength of each individual, Shoulder Strength Ratio (SSR) was calculated with bilateral external rotator strength value. SSR was calculated as equation:

$$\text{Shoulder strength ratio (\%)} = \frac{\text{Diminate shoulder}}{\text{Nondominant shoulder}}$$

Statistical analysis: We conducted t-test to compare the strength of both shoulders in each group and the differences between the players and the general population. ANOVA was performed to compare each of the four groups, three groups of players and one general group. Post hoc test of Scheffe was conducted. Statistical analysis was performed using software SPSS Version 21 and statistical significance level was defined as $p<0.05$.

RESULTS AND DISCUSSION

A total of 92 subjects were tested in this study. Three baseball players were excluded from testing because they had shoulder injury that could affects our test result. Therefore, 62 baseball players range in age from 13-28 (16±3.33) and 30 general person ranging in age from 24-47 (31±6.32) were tested. Baseball players of 36 were middle school students, 18 were high school students and 8 were adult. No participants had any shoulder pain during the time of testing. All the baseball player's dominant shoulders were pitching arm (Table 1).

The results of bilateral external rotation strength tests showed the greatest difference in adult baseball player group and the smallest difference in general public group. In all baseball players, dominant shoulders had lower strength than non-dominant shoulders but not significant and there were significant differences in muscle strength in adult baseball players. The baseball players, the general public group showed higher strength of the dominant shoulder.

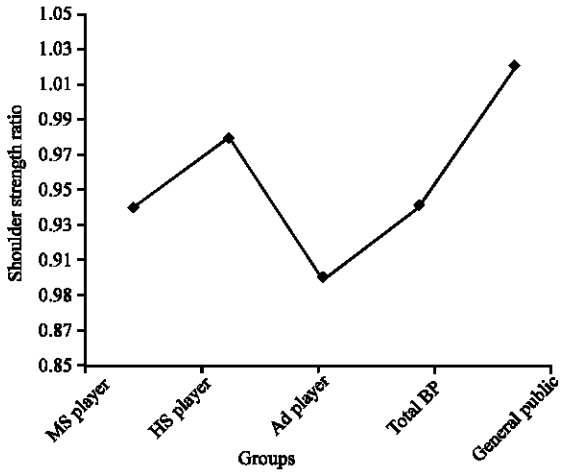

Fig. 2: Shoulder strength ratio of all groups; Middle School (MS) player, High School (HS) player, Adult (Ad) player, Total Baseball Player (Total BP) and general public

Table 1: Bilateral shoulder external rotator strength and ratio

Groups	Dominant (lbs) mean±SD	Non-dominant (lbs) mean±SD	SSR (%)	p-values
Middle school player	23.38±6.62	24.90±5.65	0.94	0.08
High school player	27.38±4.76	28.31±5.74	0.98	0.36
Adult player	28.00±4.03	31.30±5.10	0.90	0.04[b]
Total baseball player	25.14±6.38	26.08±6.18	0.94[a]	0.05
General public	25.15±6.95	24.76±6.44	1.02[a]	0.61

Significant differences ($p<0.05$) between; [a]) Total baseball player and General public; [b]) Dominant and non-dominant. Abbreviation: SSR; Shoulder strength ratio

Mean value of SSR was 0.94 in middle school players group, 0.98 in high school players and 0.9 in adult players. It was lowest at adult baseball player group and highest at middle school player group. However, there was no significant difference between any baseball player groups. The SSR showed significant difference between baseball player and general public group. Baseball player group (0.94) of mean external rotation ratio value was lower than general public group (1.02) (Fig. 2 and 3).

The results of this study showed that the SSR of baseball players was significantly lower than that of the general public. Therefore, the baseball player's dominant shoulder external rotation strength was significantly weaker than the non-dominant shoulder. Byram reported that a large eccentric force close to 400 N was required for the external rotator in the final step of pitching motion which was the follow-through phase and Gowan was confirmed by EMG experiment (Gowan *et al*., 1987; Byram *et al*., 2010). In addition, Yanagisawa found that amateur baseball players showed T2 elevation in external rotation muscles up to 96 hours after the pitching through MRI examination (Yanagisawa *et al*., 2003). Therefore, it was obvious that the pitching motion caused a negative

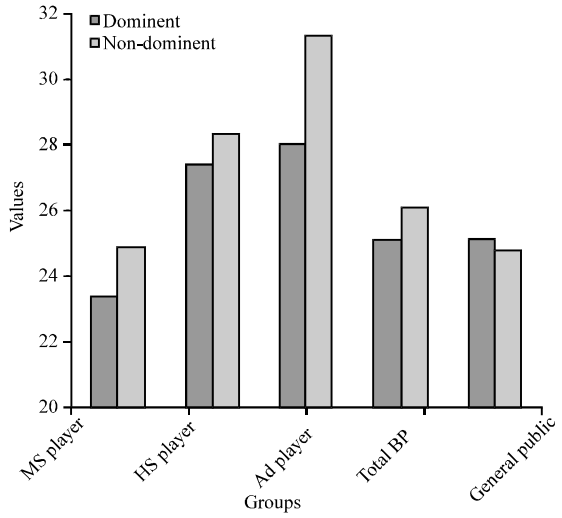

Fig 3: External rotator strength of all groups; Middle School (MS) player, High School (HS) player, Adult (Ad) player, Total Baseball Player (Total BP) and general public

physiological change due to overload in external rotator. Therefore, our results that the weakening of external rotator strength only for baseball players might be result from excessive use of rotator cuffs during pitching.

Our study showed that in the adult players of the baseball player group, the dominant shoulder external rotator was significantly weaker than non-dominant shoulder. Previous studies of professional pitcher showed that dominant shoulder external rotator was weaker than non-dominant shoulder (Wilk *et al*., 1993; Donatelli *et al*., 2000). In addition, a number of previous studies showed that for baseball players at multiple skill levels, the external rotation strength of the dominant shoulder was significantly weaker than contralateral shoulder (Cook *et al*., 1987; Ellenbecker and Mattalino, 1997; Noffal, 2003; Mullaney *et al*., 2005). Wilk *et al*. (1993) studied 150 professional baseball pitchers bilateral shoulder. External rotator strength was measured with Biodex isokinetic dynamometer at the 180 deg/sec and result showed that dominant shoulder of external rotator was significantly weaker than non-dominant shoulder. However, there were some studies of the opposite results. Those studies internal, external rotator of the university and professional baseball players of bilateral shoulder were measured with isokinetic machine and result showed there was no significant difference for external rotator strength (Perrin *et al*., 1987; Ellenbecker and Mattalino, 1997). Thus, the reason why most studies showed significant differences in bilateral external rotation strength for baseball players was first, differences in

measurement posture and item selection such as peak torque, average or test variable settings such as angular velocity. Second reason is the differences in the amount of practice hours and number of pitches participants done previous from measure.

Only adult baseball player group showed significant differences in the rotator cuff muscle strength among middle school, high school and adult baseball player group. Although, a few studies showed external rotator strength of youth baseball players was stronger, most of the previous research had significant difference in high level players (Cook *et al*., 1987; Wilk *et al*., 1993; Ellenbecker and Mattalino, 1997; Noffal, 2003; Mullaney *et al*., 2005; Trakis *et al*., 2008). The results of this study showed that the external rotator strength of youth baseball players did not show any significant weakening compared to adults. This was due to the relatively low load on the throwing shoulder compared to adults. Glenn was classified as a youth, high school, college and professional athlete and analyzed the pitching motion using a three-dimensional digitizing camera system (Fleisig *et al*., 1999). The result showed that the ball speed m/sec increased gradually from 28-37 following to group average age and the loading of shoulder posterior force (N) showed 160 in youth and 390 in professional group and the shoulder horizontal abduction torque (NM) also increased from 40-109. As studies above, there was a heavy load on the shoulders during pitching and it was especially more on high level players. In the previous study, it was found that the eccentric torque of the external rotator was predominant than the concentric internal rotator torque (Noffal, 2003). However, these measurements were far less than the 6000 deg/sec that occurred during actual pitching and are not an absolute reference because they did not concern whole body pitching mechanism. As a result in this study, the reason for significant weaker strength in the dominant shoulders of adult baseball players was higher level pitcher produced greater force on their proximal and horizontal abduction shoulder curvature during the arm deceleration phase.

The limitation of this study was that strength of participants were not consistently tested as beginning or end of the season, therefore which may result in differences of muscle strength. In addition, there was insufficient preliminary investigation and control of variables such as the amount of pitch number and training hours which could make shoulder muscles tired.

CONCLUSION

In our study, there was significant difference in bilateral external rotator strength in adult baseball players. The general public group showed higher strength of the dominant shoulder. Mean value of SSR was lowest at adult baseball player group and highest at middle school player group. The SSR showed significant difference between baseball player and general public group which of baseball player group was lower than general public group.

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