RELATIONSHIPS BETWEEN ROTATOR CUFF STRENGTH PARAMETERS AND THROWING VELOCITY OF COLLEGE BASEBALL PLAYERS

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Pitching a baseball is a complex, highly skilled movement that has been divided into four stages by sports researchers. In examining the throwing motion, researchers have: 1) attempted to find the most significant muscle groups of the upper extremity that contribute to throwing velocity (Jobe, 1987; Pedegna, 1982 and Toyoshima and Hoshikawa, 1974); 2) concluded that the shoulder and internal and external rotator groups are the most significant contributors to the throwing motion (Alderink and Kuck, 1986; Cain, Mutschler, Fu and Lee, 1987, Cook, Gray, Savinar-Nogue, Medeiros, 1987, and Pappas, Zawacki and MacCarthy, 1985); and 3) demonstrated that the motions of shoulder rotation are important during tht throwing performance (Atwater, Feltner and Dapena, 1986; Gainor, 1980; and Tullos and King, 1973).

Electromyographical (EMG) analyses have demonstrated that the rotator cuff group produces significant activity during the throwing motion and that much of this activity is eccentric, especially for the shoulder external rotators during the follow-through phase (Alderink and Kuck, 1986; Gainor, 1980, Jobe and Sisto, 1987, and Pappas, Zawacki and McCarthy, 1985). In light of these findings, this study was an attempt to focus on the question o fwhether or not the overall strength of the rotator cuff has an effect on throwing performance. Thus, the purpose of this study was to assess the degrees of relationship between various shoulder strength parameters, as measured by eccentric and concentric isokinetic testing of humeral rotation, and maximal throwing velocity of a representative team sample of collegiate baseball players.

Procedures

Subjects

Subjects consited of male volunteers (N = 13) who were members of the 1988 Oakland University baseball team. Subjects ranged in age from 18-21, had a mean playing experience of 11 years, and represented the playing positions of pitcher (3), catcher (2), infielder (4), and outfielder (4). Prior to testing and evaluation, each subject provided written informed consent. An objective physical screen was performed on the throwing arm of all subjects, including examination of gross range of motion of the cervical spine, shoulder, elbow, wrist, and hand joints. Joint play and stability of the throwing shoulder was also assessed using manual joint glides as well as a standard apprehension test. Any questionable abnormalities, such as hyper-mobility or pain, noted during the examination were deemed criteria for exclusion from the study: no subjects were excluded based on these examinations.

Instrumentation

Isokinetic Testing

All rotator cuff strength variables were assessed using a BIODEX isokinetic dynamometer and the existing algorithms of the BIODEX clinical DataStation software (1987). All attachments and accessories that were used for both concentric and eccentric data collection followed the recommendations of the BIODEX operations/ applications manual. Prior to testing, a standard set of dumbbells was used for warm up exercises.

Laser/Photocell Timing Device

A laser/photocell timing device, similar to that developed by Nelson, Larsen, Crawford and Bros (1966), consisting of two, low-strength industrial helium-neon lasers paired with photocells and a timing device (accurate to 0.1 microsecond), was used to collect all throwing velocity data (See Figure 1).

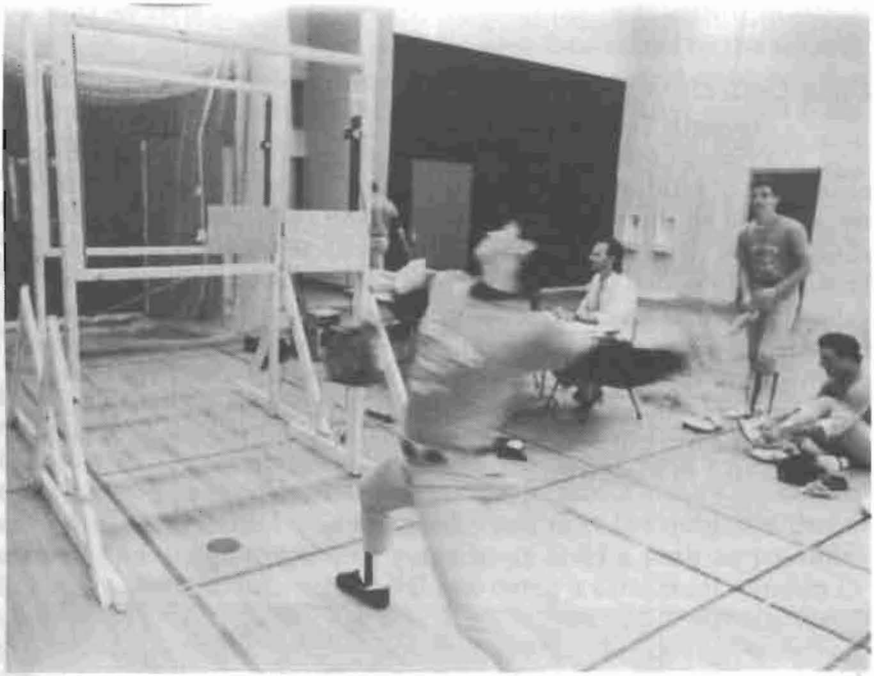

Figure 1.

This timing system was mounted on two wooden frames placed 1.2 meters part and positioned an appropriate distance from the floor. Mirrors were used within the frames in order to allow a continuous beam of light to pass back and forth in the plane. The first plane served as the entry gate while the second plane served as the exit gate. As the ball passed through the exit gate, the timer was stopped. The total elapsed time over the known test distance was used to calculate the velocity of the throw immediately following release. The validity of this timing device was established by comparing measured velocities obtained during standardized vertical drop tests with expected velocities calculated by using the force of gravity; the reliability of this instrument was estimated with the use of ANOVA and was found to have a reliability coefficient of 0.96.

Data Collection

Strength Testing

Prior to testing, each subject completed a short warm up, consisting of rotator cuff exercises using a 2.3 kg dumbbell. Subjects were seated on the Biodex testing chair and stabilized with waist and chest straps. The humeral resting pad was adjusted to 90 degrees of humeral abduction and moved proximally about 5-7 cm from the subject's medial epicondyle in order to prevent any medial elbow irritation or ulnar nerve palsy. Following adjustments to ensure proper alignment of the powerhead with the anatomical axis of the shoulder joint, the forearm was placed in a pronated position while the subject maintained a neutral wrist position throughout the test range of motion, as illustrated in Figure 2.

The end ranges of both motions were determined by the point at which the subject could no longer maintain this neutral wrist position while moving the fixture arm of the dynamometer. After several trials for warm up, familiarization, and torque scaling, the subject was requested to perform 5 repetitions with maximal effort for both the concentric and eccentric test conditions, respectively. Isokinetic test speed was set at 1.57 rad/second (90 degrees/second) for both modes. Strength variables included torque, work, and power measurements.

Throwing Velocity Measurement

Following adequate warm up, subjects were positioned as close to the entry gate as possible without hindrance to their throwing motion. This positioning enabled the ball to pass through the timing trap as soon as possible following release. Subjects were instructed to throw as hard as possible at a visual target located 2 meters behind the exit gate. This target was oriented wuch that the subject's throw entered and exited the timing gates in as level a path as possible. Subjects were also instructed to throw using a consistent windup in which one foot remained stationary. Each subject was allowed as many throwing trials as necessary until either: 1) he subjectively felt that he had reached his maximum velocity; or 2) it became evident from the velocity data that he had achieved his fastest throw. Velocity testing was conducted on the same day every two weeks during a four-week preseason period preceding competitive play.

Results

For the purposes of data analysis, the strength variables measured during isokinetic testing were subdivided into three primary variables (torque/body weight, work/body weight, and average power) and four secondary variables for both external and internal rotation. Pearson product-moment correlations were calculated for all strength variables, either concentric or eccentric, and maximum throwing velocity. Significant correlations (.05 level) were found for the secondary variables, work performed during the first one-third ROM (for eccentric/external, and eccentric/internal) and maximum work in one repetition (eccentric/external and eccentric/internal) with maximum throwing velocity (Table 1).

Table 1. Significant Correlations for Eccentric Strength Variables and Throwing Velocity

Variable	Mean (mtr-n) (ft-lb)	r-value
Max Work for 1 Rep (External Rotators)	64.23 (47.23)	.65*
Max Work for 1 Rep (Internal Rotators)	97.70 (71.84)	.61*
Work Done in First 1/3 ROM (External Rotators)	60.33 (44.36)	.63*
Work Done in First 1/3 ROM (Internal Rotators)	87.47 (64.32)	.69*

* Significant at the 0.05 level

An ANOVA with repeated measures for the three maximal throwing velocity trials demonstrated a significant difference (.01 level) in throwing velocity over the four-week period, as shown in Table 2 (velocity expressed in mph). Since a significant F-ratio was found, Scheffe's multiple comparison test was performed to compare the means of the three trials over time. The results of this procedure revealed that Time 1 (T_1) was significantly faster ($p < .01$) than both Time 2 (T_2) and Time 3 (T_3); however, T_2 was not significantly faster than T_3, as shown in Table 3.

Table 2. ANOVA with Repeated Measures for Throwing Velocity (N = 13)

	T_1	T_2	T_3
Mean Maximum Throwing Velocity (mph)	76.73	72.55	71.78
(ft/sec)	112.79	106.65	105.52
Standard Deviation (mph)	6.41	4.54	4.91
F-Ratio	16.61*		

* Significant at the 0.01 level

Table 3. Results of Scheffe's Multiple Comparisons for All Trials of Maximum Throwing Velocity

		Trial T_1	T_2	T_3
Trial	Mean	76.73	72.55	71.78
T_1	76.73	---	4.18*	4.95*
T_2	72.55		---	0.77

*Significant at the 0.01 level; t'= 3.35

Discussion

Results from this study demonstrate some relationships between eccentric strength parameters and maximum throwing velocity. These positive correlations, for both external and internal rotation, by themselves are probably not strong enough to predict throwing velocity. In comparison to the eccentric correlations, the concentric data yielded more non-significant, positive correlations which were lower in magnitude. Although probably not globally important, these results could perhaps point to future directions for sports medicine and physical therapy in terms of diagnosis, evaluation, and treatment of athletes involved in throwing events. The results of this study support reports from previous literature concerning the importance of rotator cuff strength and fitness as the most important aspect for throwing performance and the prevention of injury to the throwing shoulder. The authors recognize the limitations imposed by the 1.57 rad/sec testing speed on trying to simulate actual limb velocities incurred during maximal velocity throwing. Perhaps with advancing technology in isokinetic strength testing, sports researchers will be better able to address questions of rotator cuff strength and its relation to throwing performance.

The statistically significant decrease found in maximal throwing velocity over the four-week pre-season period was surprising.

In speculating as to why such a decrease occurred, the authors suggest the following three reasons as possible explanations: 1) player fatigue experienced over the course of pre-season conditioning and practive; 2) decreased effort during trials due to upcoming competition; and 3) throwing overuse. The clinical significance of this finding is that true measurements of throwing performance during pre-season training must be taken regularly over a substantial period of time in order to better assess the true picture of the athlete's ability.

Strength of one muscle group that contributes to athletic performance, such as that of the rotator cuff and throwing velocity, is not in itself a clear predictor of performance. AS other researchers have demonstrated, the rotator cuff is not the only contributor to the throwing motion. From our findings, we concur that accurately predicting an athlete's ability to throw a baseball involves a more complete biomechanical analysis. The contrasts between the relationships of concentric and eccentric strength with throwing velocity may help us better understand the biomechanical and physiological aspects of throwing phenomena.

Conclusions and Summary

Based on the limitations of this study, we concluded that: 1) no major significant relationships existed between external and internal humeral rotaiton strength measures and maximal throwing velocity for college baseball players; and 2) there is a significant change in throwing velocity over time during pre-season training for college baseball players. Due to the relatively small sample size used in this study these conclusions should be viewed with some caution. However, this study may have future value regarding predictions of throwing performance as well as illuminating testing and assessment strategies for the rotator cuff of athletes who are involved in throwing events. In summary, this study illustrates the importance of repeated measurement of athletes' performances in order to better comprehend their level of conditioning, especially during pre-season periods. Since throwing performance is such a multifaceted mechanical phenomenon, use of isokinetic testing may provide some benefits for the treatment of the athlete who are involved in throwing events.

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