Relationship Between Shoulder and Elbow lsokinetic Peak Torque, Torque Acceleration Energy, Average Power, and Total Work and Throwing Velocity in Intercollegiate Pitchers

By: David Pawlowski, MEd, ATC and David H. Perrin, PhD, ATC[1]

Pawlowski, D., & Perrin, D.H. (1989). Relationship between shoulder and elbow isokinetic peak torque, torque acceleration energy, average power, and total work and throwing velocity in intercollegiate pitchers. Athletic Training, 24, 129-132.

*****Note: Figures may be missing for this format of the document**
*****Note: Footnotes and endnotes indicated with parentheses**

Abstract:

The relationship between several isokinetic measures and throwing velocity was investigated in intercollegiate baseball pitchers. Ten pitchers were tested for peak torque (PT) at 60 and 240 deg/sec , and torque acceleration energy (TAE), average power (A P) and total work (T W) at 240 deg/sec during shoulder extension and flexion, shoulder internal and external rotation, and elbow flexion and extension on a Cybex isokinetic dynamometer interfaced with a Cybex Data Reduction Computer. Throwing velocity was measured with an M .P . H. K- I 5 tripod-mounted radar device during a second test session. Pearson Product Moment correlations- were computed to determine the relationship between throwing velocity and each isokinetic measure for each muscle group tested. The correlations between throwing velocity and isokinetic measures obtained during shoulder flexion and extension and elbow flexion and extension were not significant. During shoulder internal rotation (240 , , significant correlations were found between throwing velocity and PT (r = . 66, p< .05), TAE (r = .68, p<. 05), AP (r= .80, p<.01) and TW (r = .81 , p< .01). Significant correlations were also observed between throwing velocity and shoulder external rotation (240 deg/sec) PT (r = . 75 , p< . 05), AP (r= .76, p<.05), and TW (r = . 78, p< .05). Correlations between throwing velocity and shoulder internal and external rotation PT at 60 deg/sec were not significant. While these findings do not establish a cause and effect relationship, they do suggest a specificity of exercise for the shoulder internal and external rotator muscle groups. Also, because significant correlations for PT were found only at 240 deg/ sec, isokinetic assessment and training may be most appropriate at fast speeds of contraction.

Article:

The pitching motion is a series of complex movements which have been researched extensively in recent years. The biomechanics involved are well documented (4,5,8). However, the relationship of the strength and power of the involved musculature to throwing velocity is less clear. Presumably, high levels of strength and power of the muscles most involved result in the ability to impart greater velocity to the ball. Verification of this relationship would provide useful information for the design of strength and conditioning programs for both the healthy and rehabilitating pitcher. Thus, the purpose of this investigation was to determine the relationship between throwing velocity and several isokinetic strength measures of selected shoulder and elbow muscle groups in intercollegiate pitchers.

METHODOLOGY

Ten intercollegiate baseball pitchers participated in the study (age = 19.6 ± 1.4 yr, ht = 72.9 ± 1.7 in, wt = 184 ± 7.0 lb). Seven subjects were left hand dominant and three were right handed. The college pitching experience ranged from one to four years with an average of 1.7 ± .9 yr. Total pitching experience averaged 8.6 ± 4.1 yr.

---

[1] David Pawlowski is Director, Sports Injury Clinic, Tuckahoe Orthopedic Clinic in Richmond, Virginia.
David Perrin is Director, Graduate Athletic Training, University of Virginia in Charlottesville, Virginia.
EDITOR'S NOTE: Statistical significance in relation to a correlation means the correlation is reproducible; that is, if you performed the same measures on another group of subjects, you would probably (19 times out of 20if p= .05) get a similar correlation. Meaningfulness (r2) tells the strength of the relationship between the two correlated values. An r2 of .60 indicates that 60% of the variability in one factor can be accounted for by the second factor and 40% by other factors.

Subjects were screened for history of injury to either the upper or lower extremity. Those having experienced an injury in the previous year were excluded from the study.

Data collection occurred in two phases: isokinetic testing and measurement of throwing velocity. A Cybex II isokinetic dynamometer equipped with an upper body exercise table (UBXT) (Lumex, Ronkonkoma, NY) and interfaced with a Cybex data reduction computer (CDRC) was utilized for strength testing. Throwing velocity was measured with an M.P.H. K-15 (Chanute, Kansas) hand held stationary radar device.

The Cybex was calibrated before testing according to the Cybex II calibration instructions (2,3). Shoulder flexion and extension, shoulder internal and external rotation, and elbow flexion and extension were tested at speeds of 60 and 240°/ sec. Testing at 60°/sec included four consecutive repetitions of exercise, while a 25 consecutive repetition test was performed at 240°/sec. A period of stretching preceded each test. A familiarization and warm-up period was provided which consisted of three submaximal and three maximal repetitions at each test speed. A period of 30 sec was allowed between warm-up and testing, and one min was allowed between the tests at 60°/sec and 240° sec.

All tests were performed from the supine position with each subject stabilized on the UBXT with velcro straps. The joint's axis of rotation was aligned with the axis of motion of the dynamometer. Shoulder flexion and extension were tested through a range of motion from zero to 180 degrees. Elbow flexion and extension were tested through 25 to 120 degrees of motion. Shoulder internal and external rotation were tested while positioned in 90 degrees of shoulder abduction. The range of motion permitted was between 48 and 160 degrees.

The order of testing was randomly assigned by joint motion. In all cases, the slower speed was tested first. The isokinetic measures tested and utilized for the statistical analysis included peak torque (PT) at 60 and 240°/sec, and torque acceleration energy (TAE), average power (AP), and total work (TW) at 240°/sec. Peak torque, TAE, and TW were reported in foot-pounds, and AP in watts.

The second phase of testing involved the measurement of throwing velocity and occurred a minimum of three days and not longer than five days following strength testing. Subjects were allowed as many warm-up pitches as they felt necessary (72 ± 14.7, range = 49 to 103). One minute of rest was provided between the warm-up and test pitches. The test consisted of three maximally thrown pitches. Each subject was tested from an indoor mound which was exactly 60 ft, 6 in away from the throwing target (normal pitching distance). All pitches were initiated from a full wind-up.

Throwing velocity was measured with an M.P.H. hand held stationary radar device mounted on a tripod to maintain measurement angle (ten degrees) and height of the gun (35 inches). The radar device was calibrated according to operating instructions (R & R Electronics, Hammonton, NJ) before each pitch. The radar device was positioned to the right of the throwing platform for right hand subjects, and to the left for left hand subjects. Each of the three tests were measured, with the fastest throw correlated with the isokinetic measures.

RESULTS

Average throwing velocity for all subjects was 76.6 (± 3.5) mph. Table 1 presents the results of the isokinetic testing. The correlation between the isokinetic measures and throwing velocity is presented in Table 2. To determine the meaningfulness of the relationship, r^2 values were computed (Table 2).

Several significant correlations were found between throwing velocity and isokinetic measures during both shoulder internal and external rotation. For the shoulder internal rotator muscle group, significant correlations were obtained between throwing velocity and PT at 240°/sec, TAE, AP and TW. However, for PT at 240°/sec and TAE, r^2 values accounted for only 44 and 46 percent of the variance. In contrast, for AP and TW at 240°/sec, r^2 values accounted for 64 and 66 percent of the variance, respectively. Shoulder internal rotation at 60°/sec and throwing velocity were not significantly correlated.

During shoulder external rotation, significant correlations were found between throwing velocity and PT at 240°/sec, AP and TW. For these measures, r values accounted for 56, 58, and 61 percent of the variance, respectively. As with internal rotation, the relationship between throwing velocity and PT at 60°/sec was not significant.

For both shoulder internal and external rotation, the strongest relationship was demonstrated between throwing velocity and AP and TW. The range was r = .76 for shoulder external rotation AP and throwing velocity, to r=.81 for shoulder internal rotation TW and throwing velocity. No significant correlations were found between throwing velocity and any of the isokinetic measures during shoulder and elbow flexion and extension.

DISCUSSION

The results of this investigation do not establish a cause and effect relationship. However, they may suggest specificity of exercise for the shoulder internal and external rotator muscle groups. The results failed to demonstrate a similar relationship for the shoulder and elbow flexor and extensor muscle groups. The apparent prominence of the shoulder internal rotator muscle group in the throwing motion is consistent with the findings of others. Perrin et al. (9) compared the bilateral relationships of several isokinetic measures of the shoulder musculature in pitchers, swimmers, and non. athletes. The greatest bilateral difference was found in the shoulder internal rotator muscle group of the pitchers.

The role of the shoulder external rotator muscle group in the throwing motion has also received considerable attention (4,7.8). In particular, this muscle group functions primarily to decelerate the arm during the follow-through phase of the throwing motion. The prominence of the shoulder external rotator muscle group in the throwing motion has also been demonstrated by the strong relationship with several isokinetic measures in this investigation. This muscle group functions primarily through an eccentric mode of contraction (4) in the follow-through phase. Thus, additional research should focus on this muscle group with instrumentation capable of replicating the eccentric mode of contraction.

This investigation also demonstrated a significant relation- k ship between the shoulder internal and external rotator muscle groups and PT at 240°/sec, but not at 60°/sec. Pappas (8) has reported peak angular velocities during shoulder internal rotation as high as 9,000°/sec. While 240°/sec does not approach such velocities, the results of this investigation support assessment of the shoulder musculature at a faster isokinetic test velocity.

The importance of high levels of power to athletic performance is well known (1,6). The strong relationship be-tween average power and throwing velocity in this investiga-

Table 1
Isokinetic StrengthMean (± SD)

Joint Motion	PT 60		PT 240		TAE 240		AP 240		TW 240	
SIR	41.1	(7.4)	29.5	(4.4)	10.6	(1.7)	99.7	(13.2)	1273.4	(167.2)
SER	27.2	(3.4)	20.4	(2.6)	7.7	(1.4)	65.0	(9.3)	833.6	(117.5)
SF	48.1	(7.7)	34.6	(6.3)	11.3	(2.3)	110.5	(21.1)	1398.4	(294.9)
SE	66.6	(8.4)	46.6	(9.0)	14.5	(3.0)	154.9	(29.7)	1949.3	(397.1)
EF	42.6	(8.1)	27.9	(5.4)	10.2	(2.1)	89.4	(18.4)	629.8	(125.4)
EE	41.5	(10.3)	29.1	(6.9)	11.5	(2.9)	106.2	(22.8)	738.3	(176.8)

PT (peak torque), **TAE** (torque acceleration energy), **AP** (average power), **TW** (total work), SIR (shoulder internal rotation), SER(shoulder external rotation), SF (shoulder flexion), SE (shoulder extension), EF (elbow flexion), EE (elbow extension)

Table 2
Correlations Between Throwing Velocity and Isokinetic Measures r(r^2)

Joint Motion	PT 60	PT 240	TAE 240	AP 240	TW 240
SIR	.54 (.29)	.66* (.44)	.68* (.46)	.80** (.64)	.81** (.66)
SER	.35 (.12)	.75* (.56)	.55 (.30)	.76* (.58)	.78* (.78)
SF	.53 (.28)	.61 (.37)	.48 (.23)	.51 (.26)	.47 (.22)
SE	-.41 (.17)	.01 (.0001)	.06 (.003)	-.40 (.16)	-.38 (.14)

EF	-.29 (.11)	-.25 (.06)	-.07 (.004)	-.37 (.14)	-.37 (.14)
EE	-.15 (.02)	-.02 (.0004)	.04 (.0016)	-.19 (.036)	-.15 (.022)

PT (peak torque), TAE (torque acceleration energy), AP (average power), TW (total work), SIR (shoulder internal rotation), SER (shoulder* 5 external rotation), SF (shoulder flexion), SE (shoulder extension), EF (elbow flexion), EE (elbow extension).

** $p<.01$

tion seems to substantiate the important role of adequate power of the muscles most involved in the throwing motion. Also, power and total work may be more meaningful predictors of throwing velocity than more traditional measures of peak torque. Further research is needed to determine if indeed a cause and effect relationship exists between acquisition of power and enhancement of throwing velocity. The establishment of goals for the return of both peak torque and power in the rehabilitating pitcher deserves the attention of the supervising athletic trainer.

REFERENCES

1. Coyle EF, Feiring DC, Rotkis TC, Cote RW, Roby FB, Lee W. Wilmore JH: Specificity of power improvements through slow and fast isokinetic training. J App! Physiol 51:1437-1442, 1981.
2. Cybex, Division of Lumex, Inc.: Isolated Joint Testing and Exercise: A Handbook for Using the Cybex II and the U.B.X. T., Ronkonkoma, NY, 1983.
3. Cybex, Division of Lumex, Inc.: Cybex II Calibration Procedures and Record Card, Ronkonkoma, NY, 1983.
4. Jobe FW, Tibone JE, Perry J, Moynes D: An EMG analysis of the shoulder in throwing and pitching. Am J Sport Med 11:3-5, 1983.
5. Jobe FW, Moynes DR, Tibone JE, Perry J: An EMG analysis of shoulder in pitching: A second report. Am J Sport Med 12:218-220, 1984.
6. Manning JM, Dooly-Manning CR, Terrel DT, Salas E: Effects of a power circuit weight training program on power production and per. formance. J Swim Res 2:24-29, 1986.
7. Pappas AM, Zawacki RM, McCarthy CF: Rehabilitation of the pitching shoulder. Am J Sports Med 13:223-235, 1985.
8. Pappas AM, Zawacki RM, Sullivan TJ: Biomechanics of baseball pitching. Am J Sports Med 13:216-222, 1985.
9. Perrin DH, Robertson RJ, Ray RL: Bilateral isokinetic peak torque, torque acceleration energy, power, and work relationships in athletes and nonathletes. J Orthop Sport Phys Ther 9:184-189, 1987.