# RELATIONSHIP BETWEEN ISOKINETIC ARM STRENGTH AND GAME PITCHING METRICS IN DIVISION I COLLEGIATE BASEBALL PITCHERS


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## INTRODUCTION

Previous baseball pitching research has evaluated the relationship between grip and pinch strength to pitch types (8) and wrist, grip, and finger strength to ball spin rate (9) using isometric dynamometers. However, isokinetic dynamometry testing has not been frequently used with baseball pitchers.

Isokinetic dynamometry testing is often used to evaluate the effect of different types of strength interventions and levels of readiness for physical activity (6). It has been considered the clinical gold standard for strength assessment and can be used to assess a baseball pitcher's elbow and shoulder joint strength (2). An available strength measure to record the condition of the throwing arm before starting the season could be invaluable in detecting muscle weakness, deficits, and imbalances that could potentially lead to injury.

However, between the size, immobility, and cost of isokinetic dynamometers, coaches and practitioners are not often able to utilize its benefits for strength testing in the sport of baseball. Despite previous studies indicating the isokinetic testing benefits in a clinical setting, there is a lack of research exploring the relationship between isokinetic strength and sports performance (7), such as the relationship between isokinetic arm strength and baseball game performance.

In baseball, pitchers endure repetitive high intensity valgus torque on the medial side of the elbow and rotational torque of the shoulder when throwing the baseball (1,3,5). Exposure to high forces makes pitchers prime candidates for isokinetic testing to determine muscular contributions in handling peak torque in the wrist, forearm, upper arm, and shoulder in the delivery (3,4,5). Furthermore, how these strength values compare to pitcher game performance and pitch metrics are unknown.

It was hypothesized that isokinetic peak torque values at various speeds for the throwing arm (wrist, forearm, and shoulder) will correlate with game pitching metrics, such as pitch velocity, spin rate, horizontal and vertical break. Therefore, the purpose of this study was to evaluate the relationship between isokinetic arm strength and game performance in Division I collegiate baseball pitchers.

## METHODS

Thirteen Division I pitchers (age = 20.5 ± 1.5 yr; height = 185.8 ± 6.5 cm; body mass = 93.5 ± 11.6 kg; lean body mass (LBM) = 77.6 ± 6.8 kg; body fat percentage = 16.6 ± 4.4%) participated in this study. Body composition was measured with an InBody 770 (Figure 1). Prior to testing, all pitchers completed a warm-up (WU), which consisted of 6 standing upper body dynamic arm swing motions followed by a 5-minute seated upper body ergometer WU (300 kpm of work at 50 rpm and 50 W) (Figure 2). The testing was performed in a pitcher selected range of motion (ROM), with each pitcher encouraged to achieve his full ROM on each repetition. Before testing, each pitcher performed 4 warm-up repetitions at 25, 50, 75 and 100% of their perceived maximal effort at each speed. Isokinetic strength was tested during the offseason on 4 separate days using the Biodex System 3 isokinetic dynamometer in the seated position. Tests included throwing (dominant) arm shoulder diagonal abduction/adduction (Figure 3) and shoulder 90° internal/external rotation (Figure 4) at 180, 300, and 450°·sec$^{-1}$ (5, 10, and 15 repetitions, respectively), forearm pronation /supination (Figure 5) at 120, 180, and 240°·sec$^{-1}$ (5 repetitions at each speed), and wrist flexion/extension (Figure 6) at 120 and 180°·sec$^{-1}$ (5 repetitions at each speed). A 2-minute rest period was allowed between the test speeds.

## METHODS

Peak torque data were collected at each velocity using the Biodex dynamometer and software (Table 1). Additionally, individual isokinetic values were combined and divided by the number of speed settings to create an average score. Pitching metrics (Table 2) were recorded using Rapsodo In-Stadium unit during the competitive baseball season where the team was 28-31 for wins and losses and included velocity, top spin, side spin, total spin, horizontal break, and vertical break recorded for three pitch types: fastball (FB), breaking ball (BB), and change-up (CH). Mean FB velocity was 39.7 ± 0.8 m·sec$^{-1}$ (88.8 ± 1.7 mph), mean BB velocity was 35.4 ± 1.2 m·sec$^{-1}$ (79.2 ± 2.6 mph), mean CH velocity was 37.0 ± 1.0 m·sec$^{-1}$ (82.7 ± mph).

Correlation values (Table 3) were classified by significance using Pearson's critical $r$ value for alpha levels $\alpha = 0.05$ ($r$ (11) = 0.553, $p < 0.05$) and $\alpha = 0.01$ ($r$ (11) = 0.684, $p < 0.01$) and color-coded by strength of correlation: moderate (green: 0.553 - 0.599), moderately high (orange: 0.600 – 0.799), and high (yellow: 0.800 – 1.0).

## RESULTS

**Table 1.** Isokinetic strength (mean and ±SD) metrics for wrist, forearm, and shoulder at various speeds (N = 13).

| Seated Wrist Extension Flexion | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wrist Extension Flexion @120°/s | | Wrist Extension Flexion @180°/s | | Average Wrist Extension Flexion | | | | | | | |
| DPTE 120 | DPTF 120 | DPTE 180 | DPTF 180 | ADPTE | ADPTF | ADPTE RS | ADPTF RS | ADPTE LMRS | ADPTF LMRS | | |
| 7.98 | 14.54 | 7.49 | 14.44 | 7.74 | 14.49 | 0.0381 | 0.0712 | 0.0455 | 0.0849 | | |
| 1.38 | 2.77 | 1.42 | 3.05 | 1.35 | 2.86 | 0.0076 | 0.0150 | 0.0084 | 0.0151 | | |
| **Seated Forearm Supination Pronation** | | | | | | | | | | | |
| **Forearm Sup/Pro @120°/s** | | **Forearm Sup/Pro @180°/s** | | **Forearm Sup/Pro @240°/s** | | **Average Forearm Supination Pronation** | | | | | |
| DPTS 120 | DPTP 120 | DPTS 180 | DPTP 180 | DPTS 240 | DPTP 240 | ADPTS | ADPTP | ADPTS RS | ADPTP RS | ADPTS LMRS | ADPTP LMRS |
| 7.84 | 9.78 | 7.35 | 9.18 | 7.36 | 9.02 | 7.52 | 9.33 | 0.0368 | 0.0459 | 0.0439 | 0.0548 |
| 1.47 | 2.32 | 1.29 | 2.16 | 1.30 | 1.84 | 1.19 | 1.95 | 0.0060 | 0.0109 | 0.0055 | 0.0117 |
| **Seated Shoulder Diagonal Away (Abduction) and Towards (Adduction)** | | | | | | | | | | | |
| **Diagonal Away Towards @180°/s** | | **Diagonal Away Towards @300°/s** | | **Diagonal Away Towards @450°/s** | | **Average Shoulder Diagonal Away Towards** | | | | | |
| DPTA 180 | DPTT 180 | DPTA 300 | DPTT 300 | DPTA 450 | DPTT 450 | ADPTA | ADPTT | ADPTA RS | ADPTT RS | ADPTA LMRS | ADPTT RS |
| 57.83 | 77.25 | 44.22 | 73.74 | 26.78 | 45.67 | 42.94 | 65.55 | 0.2101 | 0.3214 | 0.2524 | 0.3841 |
| 15.52 | 14.24 | 12.22 | 13.68 | 10.23 | 10.67 | 11.86 | 12.07 | 0.0574 | 0.0607 | 0.0708 | 0.0633 |
| **Seated Shoulder External and Internal Rotation at 90°** | | | | | | | | | | | |
| **ER and IR at 90° @180°/s** | | **ER and IR at 90° @300°/s** | | **ER and IR at 90° @450°/s** | | **Average Shoulder External and Internal Rotation at 90°** | | | | | |
| DPTER 180 | DPTIR 180 | DPTER 300 | DPTIR 300 | DPTER 450 | DPTIR 450 | ADPTER | ADPTIR | ADPTER RS | ADPTIR RS | ADPTER LMRS | ADPTIR LMRS |
| 41.45 | 50.94 | 38.62 | 48.46 | 31.32 | 42.52 | 37.13 | 47.31 | 0.1830 | 0.2325 | 0.2187 | 0.2775 |
| 6.07 | 14.01 | 6.10 | 12.73 | 5.27 | 11.94 | 5.53 | 12.66 | 0.0356 | 0.0612 | 0.0374 | 0.0683 |

**Table 2.** Mean and ±SD Rapsodo game pitching metrics and game pitching performance statistics (N =13).

| Rapsodo Pitching Metrics | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fastball** | | | | | | **Breaking Ball** | | | | | | **Change-up** | | | | | |
| FB V | FB TS | FB SS | FB TOS | FB HB | FB VB | BB V | BB TS | BB SS | BB TOS | BB HB | BB VB | CH V | CH TS | CH SS | CH TOS | CH HB | CH VB |
| 88.8 | 933.83 | 400.48 | 1809.66 | 6.55 | 13.58 | 79.72 | -157.2 | 67.11 | 1962.16 | -2.23 | -0.9 | 82.72 | 638.3 | 447 | 1651.22 | 7.29 | 8.13 |
| 1.72 | 257.6 | 710.92 | 129.28 | 11.10 | 3.89 | 2.55 | 336.5 | 154.74 | 207.34 | 5.81 | 4.50 | 2.26 | 290.30 | 718.00 | 181.10 | 11.30 | 4.14 |
| **Season Pitching Performance Statistics** | | | | | | | | | | | | | | | | | |
| ERA | Wins | Losses | Innings Pitched (IP) | Hits (H) | H/IP | H/9IP | Runs | Earned Runs | Walks (W) | W/IP | W/9IP | Strike Outs (SO) | SO/IP | SO/9IP | WHIP | WHIP/9 IP | Opp B/AVG |
| 7.73 | 1.69 | 2.23 | 34.66 | 43.23 | 1.29 | 11.70 | 27.08 | 25.00 | 14.92 | 0.65 | 5.839 | 28.23 | 0.782 | 7.04 | 1.95 | 17.50 | 0.310 |
| 4.74 | 2.43 | 1.96 | 25.11 | 31.35 | 0.35 | 3.15 | 17.26 | 16.71 | 6.82 | 0.41 | 3.647 | 23.81 | 0.276 | 2.49 | 0.63 | 5.70 | 0.07 |

**Table 3.** Pearson product-moment correlations between isokinetic strength values and pitching metrics.

| | Forearm Supination and Pronation | | | | Shoulder Diagonal Away (Abduction) and Toward (Adduction) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Metrics*** | DPTP 180 | DPTP 240 | ADPTS RS | ADPTS LMRS | DPTA 180 | DPTT 180 | DPTA 300 | DPTA 450 | DPTT 450 | AVG DPTA | AVG DPTT | ADPTA RS | ADPTA LMRS |
| FB V | -0.196 | 0.263 | **0.564*** | 0.473 | **-0.557*** | -0.151 | -0.454 | -0.319 | -0.415 | -0.490 | -0.232 | -0.379 | -0.507 |
| FB TS | 0.453 | -0.136 | -0.124 | 0.018 | **0.866**** | 0.412 | **0.636*** | **0.687**** | **0.655*** | **0.794** | 0.482 | **0.577*** | **0.665*** |
| FB SS | -0.202 | 0.191 | 0.360 | 0.327 | -0.460 | -0.085 | -0.218 | -0.169 | -0.387 | -0.324 | -0.173 | -0.213 | -0.299 |
| FB TOS | **0.644*** | 0.451 | -0.003 | 0.164 | 0.430 | 0.214 | 0.365 | 0.467 | 0.392 | 0.447 | 0.223 | 0.240 | 0.315 |
| FB HB | -0.452 | -0.075 | 0.219 | 0.171 | -0.518 | -0.169 | -0.298 | -0.247 | -0.520 | -0.399 | -0.260 | -0.271 | -0.342 |
| FB VB | 0.131 | -0.369 | -0.300 | -0.237 | **0.661*** | 0.448 | 0.420 | 0.428 | **0.604*** | **0.556** | 0.493 | 0.351 | 0.427 |
| BB V | -0.044 | 0.410 | **0.697**** | **0.605*** | -0.526 | -0.165 | -0.416 | -0.411 | -0.423 | -0.491 | -0.244 | -0.292 | -0.435 |
| BB TS | -0.341 | 0.040 | **0.581*** | 0.512 | -0.494 | -0.030 | -0.505 | -0.494 | -0.467 | -0.531 | -0.170 | -0.449 | **-0.556*** |
| BB SS | 0.136 | 0.474 | 0.517 | 0.508 | -0.198 | -0.142 | -0.213 | -0.279 | -0.282 | -0.239 | -0.114 | -0.114 | -0.181 |
| BB TOS | 0.302 | 0.082 | -0.293 | -0.184 | 0.188 | -0.406 | 0.383 | 0.469 | -0.055 | 0.348 | -0.351 | 0.401 | 0.467 |
| BB HB | 0.301 | 0.110 | -0.188 | -0.152 | 0.316 | 0.010 | 0.039 | -0.038 | 0.262 | 0.140 | 0.105 | 0.053 | 0.123 |
| BB VB | -0.300 | -0.037 | 0.562 | 0.489 | -0.362 | 0.058 | -0.318 | -0.280 | -0.199 | -0.348 | -0.021 | -0.216 | -0.324 |
| CH V | 0.180 | **0.609*** | **0.602*** | **0.567*** | -0.368 | -0.244 | -0.208 | -0.056 | -0.247 | -0.248 | -0.215 | -0.117 | -0.230 |
| CH TS | 0.191 | -0.265 | -0.244 | -0.197 | **0.625*** | 0.519 | 0.355 | 0.405 | **0.772**** | 0.511 | **0.595*** | 0.277 | 0.344 |
| CH SS | -0.422 | -0.069 | 0.255 | 0.179 | -0.514 | -0.133 | -0.329 | -0.234 | -0.452 | -0.405 | -0.228 | -0.277 | -0.370 |
| CH TOS | 0.004 | 0.191 | 0.046 | 0.128 | -0.041 | -0.344 | 0.207 | 0.384 | -0.371 | 0.163 | -0.290 | 0.174 | 0.192 |
| CH HB | -0.443 | -0.079 | 0.287 | 0.196 | -0.552 | -0.099 | -0.388 | -0.333 | -0.378 | -0.470 | -0.179 | -0.324 | -0.423 |
| CH VB | 0.269 | -0.061 | 0.047 | 0.091 | **0.565*** | **0.584*** | 0.520 | 0.423 | **0.677*** | 0.547 | **0.618*** | 0.388 | 0.413 |

* = $p < 0.05$, ** = $p < 0.01$

FB = fastball; V = velocity; TS = top (back) spin; SS = side spin; TOS = total spin; HB = horizontal break; VB = vertical break; BB = breaking ball; CH = change-up; DPTE = dominant peak torque wrist extension; DPTF = dominant peak torque wrist flexion; 120 = 120° /sec; 180 = 180° /sec; ADPTE = average dominant peak torque wrist extension; ADPTF = average dominant peak torque wrist flexion; RS = relative strength; LMRS = lean body mass relative strength; DPTS = dominant peak torque forearm supination; DPTP = dominant peak torque forearm pronation; 240 = 240° /sec; ADPTS = average dominant peak torque forearm supination; ADPTP = average dominant peak torque forearm pronation; DPTA = dominant peak torque shoulder abduction (away); DPTT dominant peak torque shoulder adduction (toward); 300 = 300° /sec; 450 = 450° /sec; ADPTA = average dominant peak torque shoulder abduction; ADPTT = average dominant peak torque shoulder adduction; DPTER = dominant peak torque shoulder external rotation; DPTIR = dominant peak torque shoulder internal rotation; ADPTER = average dominant peak torque shoulder external rotation; ADPTIR = average dominant peak torque shoulder internal rotation.

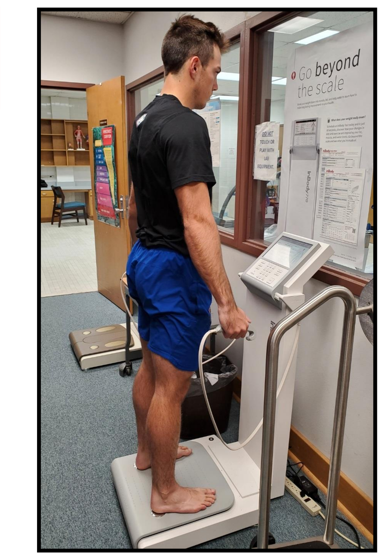

**Figure 1.** InBody 770 BIA body composition.

**Figure 2.** Upper body ergometer warm-up.

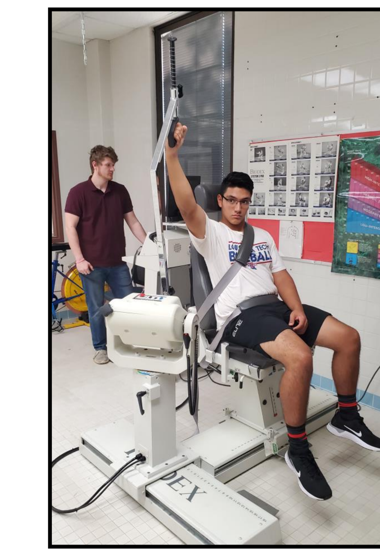

**Figure 3.** Isokinetic shoulder diagonal abduction and adduction.

**Figure 4.** Isokinetic shoulder external and internal rotation at 90˚

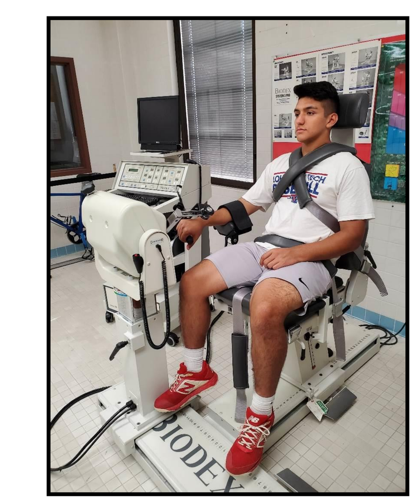

**Figure 5.** Isokinetic forearm supination and pronation.

**Figure 6.** Isokinetic wrist extension and flexion.

## CONCLUSIONS

Significant relationships existed between isokinetic forearm supination and pronation and FB velocity and total spin; BB velocity, top spin, total spin, and vertical break; and CH velocity. Isokinetic shoulder abduction and adduction had significant relationships with FB velocity, top spin, vertical break; and CH top spin and vertical break during games.

## PRACTICAL APPLICATIONS

An isokinetically stronger arm relates to better pitching metrics, which could help the team be successful. Coaches and practitioners should promote data-based individualized throwing arm strength programs because lower strength could equate to reduced game performance and team losses.

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