RELATIONSHIP BETWEEN ISOKINETIC ARM STRENGTH AND GAME PERFORMANCE 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 pitchers' game performance. 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 the 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° external/internal rotation (Figure 4) at 180, 300, and 450°·sec^{-1} (5, 10, and 15 repetitions, respectively), forearm supination/pronation (Figure 5) at 120, 180, and 240°·sec^{-1} (5 repetitions at each speed), and wrist extension/flexion (Figure 6) at 120 and 180°·sec^{-1} (5 repetitions at each speed).

METHODS

A 2-minute rest period was allowed between the test speeds. 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. Game pitching performance data (Table 2); earned-run average (ERA), wins, losses, innings pitched (IP), hits (H), H/IP, H/9 IP, runs, earned runs, base on balls (BB), BB/IP, BB/9IP, strikeouts (SO), SO/IP, SO/9IP, walks plus hits per inning pitched (WHIP), WHIP/9IP, and opponents' batting average (BA), were acquired after the competitive season through the official university athletics website.

Correlation values (Table 3) were classified by significance using Pearson's product-moment 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	AVG DPTE	AVG DPTF	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 Pronation Supination											
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	AVG DPTS	AVG DPTP	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 and Towards											
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	AVG DPTA	AVG DPTT	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	AVG DPTER	AVG DPTIR	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						Chane-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	447.00	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	4.5	2.26	290.3	718.00	181.1	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	1.3	11.7	27.08	25	14.92	0.65	5.84	28.23	0.78	7.04	1.95	17.50	0.31
4.74	2.43	1.96	25.11	31.35	0.35	3.15	17.26	16.71	6.82	0.41	3.65	23.81	0.28	2.49	0.63	5.70	0.07

Table 3. Pearson product-moment correlations between isokinetic strength values and pitching performance statistics.

	Wrist Extension and Flexion					Shoulder Diagonal Away (Abduction) and Toward (Adduction)						Shoulder External Internal Rotation at 90°				
Metrics	DPTE 180	AVG DPTE	ADPTE RS	ADPTE LMRS	ADPTF LMRS	DPTA 180	DPTA 300	DPTA 450	AVG DPTA	ADPTA RS	ADPTA LMRS	DPTER 300	DPTER 450	AVG DPTER	ADPTER RS	ADPTER LMRS
Earn-Run Average	-0.514	-0.387	-0.368	-0.462	0.143	-0.287	-0.407	**-0.553***	-0.424	-0.442	-0.473	-0.325	-0.454	-0.347	-0.297	-0.410
Wins	0.342	0.386	0.033	0.198	0.375	**0.693****	0.469	**0.600***	**0.636***	0.349	0.476	0.131	0.220	0.164	-0.162	-0.013
Lose	0.252	0.294	-0.039	0.149	0.313	0.418	0.456	0.517	0.487	0.297	0.420	0.038	-0.022	0.024	-0.290	-0.122
Innings Pitched (IP)	0.313	0.345	-0.036	0.165	0.381	**0.680***	**0.602***	**0.684****	**0.700****	0.426	**0.572***	0.033	0.039	0.030	-0.315	-0.140
Hits	0.178	0.225	-0.185	0.004	0.458	**0.588***	0.487	**0.563***	**0.586***	0.283	0.431	-0.110	-0.147	-0.124	-0.483	-0.329
Hits/IP	**-0.685****	-0.550	**-0.571***	**-0.633***	0.177	-0.342	-0.478	**-0.600***	-0.486	-0.552	-0.546	**-0.570***	**-0.718****	**-0.616***	**-0.570***	**-0.665***
Hits/9 IP	**-0.685****	-0.550	**-0.571***	**-0.633***	0.177	-0.342	-0.478	**-0.600***	-0.486	-0.552	-0.546	**-0.570***	**-0.718****	**-0.616***	**-0.570***	**-0.665***
Runs	0.182	0.255	-0.228	-0.039	**0.568***	**0.566***	0.376	0.462	0.509	0.163	0.314	-0.093	-0.180	-0.113	-0.544	-0.394
Earned Runs	0.205	0.278	-0.201	-0.018	**0.571***	**0.563***	0.388	0.465	0.512	0.175	0.319	-0.064	-0.148	-0.081	-0.513	-0.367
Base on Balls (BB)	0.164	0.175	-0.121	-0.054	0.476	0.052	0.177	0.305	0.171	0.004	0.043	0.052	0.016	0.061	-0.247	-0.188
BB/IP	-0.298	-0.308	-0.096	-0.289	-0.038	-0.466	-0.417	**-0.575***	-0.511	-0.381	-0.504	0.035	-0.062	0.035	0.200	0.027
BB/9IP	-0.298	-0.308	-0.096	-0.289	-0.038	-0.466	-0.417	**-0.575***	-0.511	-0.381	-0.504	0.035	-0.062	0.035	0.200	0.027
Strike Outs (SO)	0.259	0.269	-0.026	0.150	0.307	0.552	0.536	**0.669***	**0.617***	0.383	0.514	0.069	0.143	0.091	-0.189	-0.023
SO/IP	0.283	0.157	0.251	0.284	-0.182	-0.009	0.132	0.263	0.117	0.174	0.179	0.322	0.478	0.346	0.387	0.458
SO/9IP	0.283	0.157	0.251	0.284	-0.182	-0.009	0.132	0.263	0.117	0.174	0.179	0.322	0.478	0.346	0.387	0.458
WHIP	**-0.570***	-0.501	-0.377	-0.534	0.074	-0.487	-0.531	**-0.699****	**-0.596***	-0.549	**-0.624***	-0.293	-0.437	-0.318	-0.187	-0.350
WHIP/9IP	**-0.570***	-0.501	-0.377	-0.534	0.074	-0.487	-0.531	**-0.699****	**-0.596***	-0.549	**-0.624***	-0.293	-0.437	-0.318	-0.187	-0.350
Batting Average	**-0.733****	**-0.584***	**-0.641***	**-0.697****	0.245	-0.351	-0.510	**-0.568***	-0.492	**-0.587***	**-0.573***	**-0.596***	**-0.755****	**-0.650***	**-0.640***	**-0.733****

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

W = wins; IP = innings pitched; H = hits; H/IP = hits per innings pitched; H/9IP = hits per nine innings pitched; R = runs; ER = earned runs; BB/IP = walks per innings pitched; BB/9IP = walks per nine innings pitched; SO = strikeouts; WHIP = walks plus hits per innings pitched; WHIP/9IP = walks plus hits per nine innings pitched; B/AVG = batter's average; DPTE 180 = dominant peak torque wrist extension @180° ·sec; AVG DPTE = average dominant peak torque wrist extension; ADPTE RS = average dominant peak torque wrist extension relative strength; ADPTE LMRS = average dominant peak torque wrist extension lean mass relative strength; ADPTF LMRS = average dominant peak torque wrist flexion lean mass relative strength; DPTA 180 = dominant peak torque shoulder abduction @ 180° ·sec; DPTA 300 = dominant peak torque shoulder abduction @ 300° ·sec; DPTA 450 = dominant peak torque shoulder abduction @ 450° ·sec; AVG DPTA = average dominant peak torque shoulder abduction; ADPTA RS = average dominant peak torque shoulder abduction relative strength; ADPTA LMRS = average dominant peak torque shoulder abduction lean mass relative strength; DPTER 300 = dominant peak torque shoulder external rotation @ 300° ·sec; DPTER 450 = dominant peak torque shoulder external rotation @ 450° ·sec; AVG DPTER = average dominant peak torque shoulder external rotation; ADPTER RS = average dominant peak torque shoulder external rotation relative strength; ADPTER LMRS = average dominant peak torque shoulder external rotation lean mass relative strength

Figure 1. InBody 770 BIA body composition.

Figure 2. Upper body ergometer warm-up.

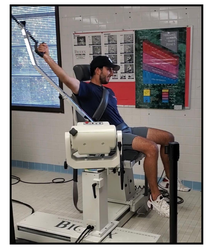

Figure 3. Isokinetic shoulder diagonal abduction and adduction.

Figure 4. Isokinetic shoulder external and internal rotation at 90°

Figure 5. Isokinetic forearm supination and pronation.

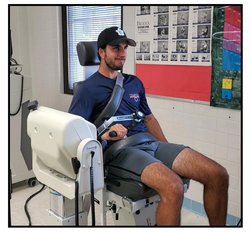

Figure 6. Isokinetic wrist extension and flexion.

CONCLUSIONS

Greater isokinetic wrist extension strength values related to less hits per inning, hits per 9 innings, WHIP, and opponent's batting average. Greater shoulder diagonal abduction strength values at various speeds related to more wins, IP, and SO as well as lower ERA, less H/IP, H/9IP, BB, WHIP, and opponent's BA. Greater shoulder external rotation strength values related to lower H/IP, H/9IP, and opponent's BA.

PRACTICAL APPLICATIONS

An isokinetically stronger arm relates to better pitching game pitching performance, which could help produce more wins. Coaches and practitioners should promote data-based individualized throwing arm strength programs because lower arm strength could result in poor game performance and team losses.

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