AN INVESTIGATION INTO SEASONAL CHANGES OF POWER AND FATIGUE IN COLLEGIATE BASEBALL PITCHERS

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This study aimed to investigate changes in power and fatigue of collegiate baseball pitchers throughout a season to determine injury risk. Isokinetic, mobility, and performance test records were reviewed for 18 male NCAA-I baseball athletes. Testing was performed during the offseason, season start, and end of non-conference play and included m, medicine ball throws, hop testing, and 3-speed isokinetic testing. Statistical analysis determined that the kneeling medicine ball throw, 6-m hop, and several isokinetic outcomes decreased throughout the season. Using a combination of medicine ball throws, hop testing, and isokinetic testing at specific times during a season may provide insight into the overall fatigue level and injury risk within baseball pitchers.

KEYWORDS: **ISOKINETICS, HOP TESTING, MEDICINE BALL**

INTRODUCTION

Baseball pitching is a fatiguing process, not only for a single throwing session but over the season. As a complex and coordinated movement requiring a transfer of force throughout the whole body, the overall performance of a baseball pitcher is dependent on the ability to generate and transfer force onto a baseball at a high velocity (Lin et al., 2003). The overhand pitching motion in baseball is particularly susceptible to muscular fatigue, subsequent negative performance changes, and increased injury risk (Fortenbaugh et al., 2009). Muscular fatigue can drastically decrease performance and lead to serious injury if not regulated (Stone & Schilling, 2020). Muscular fatigue is the most common deterrent to continued performance, directly affecting the power output and resulting torque about the joint, impacting the consistency of throwing at high velocity during a single game and throughout a season (Oliver et al., 2016; Stone & Schilling, 2020)

Overall, an overhand pitch is a dynamic and violent movement placing a large magnitude of stress on the shoulder joint, making it vulnerable to muscular fatigue and injury (Urbin et al., 2013). Muscular fatigue in baseball pitchers impacts their athletic performance and increases injury risk by altering the throwing mechanics, proprioception response, and power output of the muscle (Oliver et al., 2016; Stone & Schilling, 2020). The impact of injuries occurs throughout all levels of baseball competition, and evidence of the need for consistent monitoring for muscular fatigue and power changes to determine the athlete's status. Current monitoring programs are not effective in detecting power changes and fatigue effectively. A more dynamic and whole-body approach to monitoring will better detect power changes and allow appropriate intervention. This study investigated the ability to detect fatigue-related performance decreases throughout a season using total body power-related measurements.

METHODS

The records of 21 male baseball pitchers (20.66 + 1.24 year; 1.88 + 0.07 m; 94.06 + 12.46 kg) from an NCAA Division I baseball team were accessed initially. The group consisted of 18 right-handed and three left-handed pitchers. Eighteen of the 21 participants were tested three times during the season and had their data included in this study, leaving 15 right-handed and three left-handed pitchers in the data set. Testing was done before preseason training, the start of the season, and before conference play

Procedures

Floor Testing. Participants performed trials of the following hop tests: single-leg 6-meter hop jump, single-leg triple hop, and single-leg crossover triple hop. The distance for three successful trials was recorded from the heel to the starting point to the nearest centimeter. Participants performed the following medicine ball tests: seated medicine ball throw and kneeling medicine ball throw. The distance for three successful trials was recorded at the point of impact to the floor to the nearest centimeter.
Isokinetic Testing. Participants were tested using a calibrated isokinetic device (Cybex Humac Norm, Computer Sports Medicine, Inc., Stoughton, MA, USA) using the standing isokinetic shoulder internal (IR) and external rotation (ER) test. The isokinetic test consisted of 3 velocities of concentric testing in the order of 60º/sec, 180 º/sec, and 240 º/sec.
Data Processing. Measurements were recorded into a spreadsheet (Excel, Microsoft Corporation, Redmond, WA) for the three successful trials of each hop test and medicine ball throw. An average distance was calculated for each floor test. Peak torque, average torque, time to peak torque, and fatigue index outcomes were pulled from the IR and ER isokinetic test records.
Statistical Analysis
Isokinetic and floor test variables were analyzed through a one-way analysis of variance with post-hoc testing to examine differences from baseline (October) throughout two in-season time points (January and March). All statistical analyses were performed using SPSS software (Version 26, SPSS, Inc., IMB Inc., Chicago, IL) with an a priori alpha level set at p # 0.05.

RESULTS

Table 1 details the mean & standard deviation of significant test variables collected from the 21 male baseball pitchers (20.66 + 1.24 year; 1.88 + 0.07 m; 94.06 + 12.46 kg).

Table 1. Mean & standard deviation of performance outcomes for each testing session.

	October	January	March
Kneeling Medicine Ball (m)	8.34 ± 1.08	7.95 ± 0.70	7.68 ± .65
6M SL Hop-Right (m)	1.86 ± 0.26	2.04 ± 0.27	2.03 ± 0.24
6M SL Hop-Left (m)	1.82 ± 0.19	1.97 ± 0.25	2.07 ± 0.20
IR Peak Torque Right (60°/sec)	42.95 ± 9.42	40.07 ± 5.66	35.89 ± 6.76
IR Peak Torque Left (60°/sec)	42.19 ± 8.24	37.95 ± 6.92	35.22 ± 5.87
ER Peak Torque Right (60°/sec)	26.71 ± 5.48	25.37 ± 4.99	23.11 ± 4.04
IR Avg Torque Right (60°/sec)	48.24 ± 9.82	43.63 ± 7.42	38.56 ± 6.34
ER Avg Torque Right (60°/sec)	28.33 ± 5.35	24.68 ± 4.62	22.50 ± 4.06
ER Avg Torque Left (60°/sec)	27.14 ± 4.86	25.11 ± 4.88	22.22 ± 5.26
IR Peak Torque Left (180°/sec)	35.43 ± 7.38	32.00 ± 6.64	29.67 ± 5.59
ER Peak Torque Right (180°/sec)	24.43 ± 9.70	18.89 ± 4.32	18.28 ± 3.79
ER Peak Torque Left (180°/sec)	22.14 ± 9.31	17.89 ± 2.89	16.39 ± 3.18
ER Avg Torque Left (180°/sec)	46.05 ± 10.27	41.58 ± 7.14	36.50 ± 7.42
ER Peak Torque Right (240°/sec)	22.10 ± 7.44	16.26 ± 4.07	16.00 ± 3.80
ER Peak Torque Left (240°/sec)	18.05 ± 3.44	15.26 ± 2.96	13.28 ± 2.85
ER Avg Torque Right (240°/sec)	52.43 ± 16.61	41.16 ± 12.27	38.72 ± 9.42
ER Avg Torque Left (240°/sec)	45.05 ± 9.34	36.84 ± 9.85	32.78 ± 7.67

Floor testing. There was a statistically significant difference between testing sessions for the kneeling medicine ball test as determined by one-way ANOVA (F(2,164) = 8.664, *p*<.001). A Bonferroni post-hoc test revealed that throwing distance significantly differed between October

(8.34 ± 1.08 m, p = .033) and March (7.68 ± .65 m) testing sessions. There was also a statistically significant difference between the testing sessions for the 6 M timed hop for the right leg (F(2,164) = 8.493, p<.001), left leg (F(2,164) = 20.223, p<.001), and limb symmetry outcomes (F(2,164) = 8.531, p<.001). A Bonferroni post-hoc test revealed that time significantly differed for 6 M timed hop for the right leg when comparing October (1.86 ± 0.26 sec) to January (2.04 ± 0.27 sec, p = .0013) and to March (2.03 ± 0.24 sec, p = .0017), the left leg when comparing October (1.82 ± 0.19 sec) to January (1.97 ± 0.25 sec, p = .0036), to March (2.07 ± 0.20 sec, p = .0030), and when comparing January testing to March (p = < .001).

Isokinetic testing. There was a statistically significant difference between testing sessions for the isokinetic testing outcomes as tested by a one-way ANOVA with Bonferroni post hoc analysis. Peak torque at 60 deg/sec for internal rotation of the right arm (F(2,55) = 4.321, p=.018) and the left arm (F(2,55) = 4.643, p = .014) was significant. The Bonferroni post-hoc test revealed that internal rotation peak torque at 60 deg/sec significantly differed from October (42.95 ± 9.42 deg/sec) to March (35.89 ± 6.76 deg/sec, p = .015) for the right arm and from October (42.19 ± 8.24 deg/sec) to March (35.22 ± 5.87 deg/sec, p = 0.12) for the left arm. The peak torque for external rotation of the right arm at 60 deg/sec (F(2,55) = 4.561, p = .015) was significant when comparing the October test session (26.71 ± 5.48 deg/sec) to March (23.11 ± 4.04 deg/sec, p = .012) during post hoc testing. The average torque for internal rotation of the right arm at 60 deg/sec was significant (F(2,55) = 6.938, p=.002). The Bonferroni post-hoc test revealed that the internal rotation average torque at 60 deg/sec significantly differed from October (48.24 ± 9.82 deg/sec) to March (38.56 ± 6.34 deg/sec, p = .001) for the right arm. Average torque for external rotation of the right arm at 60 deg/sec (F(2,55) = 7.590, p=.001) and the left arm (F(2,55) = 4.720, p=.013). The Bonferroni post-hoc test revealed that the external rotation average torque at 60 deg/sec significantly differed from October (28.33 ± 5.35 deg/sec) to March (22.50 ± 4.06 deg/sec, p< .001) for the right arm and from October (27.14 ± 4.86 deg/sec) to March (22.22 ± 5.26 deg/sec, p < .001) for the left arm.

Peak torque at 180 deg/sec for internal rotation of the left arm (F(2,55) = 3.750, p=.030). The post-hoc test revealed that the average torque for internal rotation at 180 deg/sec of the left arm significantly differed from October (35.43 ± 7.38 deg/sec) to March (29.67 ± 5.59 deg/sec, p = .027) for the left arm. Peak torque at 180 deg/sec for external rotation of the right arm (F(2,55) = 5.135, p=.009) and the left arm (F(2,55) = 4.724, p=.013). The post-hoc testing indicated that the external rotation average torque at 1800 deg/sec significantly differed from October (24.43 ± 9.70 deg/sec) to January (18.89 ± 4.32 deg/sec, p = .035) and from October to March (18.28 ± 3.79 deg/sec, p = .035) for the right arm while the left arm differed from October (22.14 ± 9.31 deg/sec) to March (16.39 ± 3.18 deg/sec, p = .015). Average torque at 180 deg/sec for internal rotation of the left arm (F(2,55) = 6.133, p=.004). The internal rotation of the left arm differed from October (46.05 ± 10.27 deg/sec) to March (36.50 ± 7.42 deg/sec, p = .003) at 180 deg/sec.

Peak torque at 240 deg/sec for external rotation of the right arm (F(2,55) = 7.935, p<.001) and the left arm (F(2,55) = 11.618, p<.001). The post-hoc testing indicated that the external rotation average torque at 240 deg/sec significantly differed from October (22.10 ± 7.44 deg/sec) to January (16.26 ± 4.07 deg/sec, p = .004) and from October to March (16.00 ± 3.80 deg/sec, p = .003) for the right arm. The peak torque of the left arm also differed from October (18.05 ± 3.44 deg/sec) to January (15.26 ± 2.96 deg/sec, p = .020) and to March (13.28 ± 2.85 deg/sec, p<.001) for 240 deg/sec external rotation. Average torque at 240 deg/sec for external rotation of the right arm (F(2,55) = 6.023, p<.001) and the left arm (F(2,55) = 9.442, p<.001). The post-hoc testing indicated that the external rotation average torque at 240 deg/sec significantly differed from October (52.43 ± 16.61 deg/sec) to January (41.16 ± 12.27 deg/sec, p = .035) and from October to March (38.72 ± 9.42 deg/sec, p = .035) for the right arm while the left arm differed from October (45.05 ± 9.34 deg/sec, p = .029) to January and from October to March (16.39 ± 3.18 deg/sec, p = .007).

DISCUSSION

This study aimed to investigate the ability to detect fatigue-related performance decreases throughout a season using total body power-related measurements in a group of NCAA D-I pitchers. The findings allow descriptive characteristics to be reported for this group of pitchers, allowing an examination of potential changes in power production during the season. Our results provide insight into the relationships between field and isokinetic testing and athlete performance. Our hypotheses were that field, and isokinetic testing performance outcomes would decrease at each testing point. Statistical analysis determined that all testing outcomes decreased from October to March test points; not all decreases were significant. Field testing outcomes for the kneeling medicine ball throw and the 6-meter single-leg hop test of both legs decreased significantly. The distance the pitchers threw decreased from the initial test across the remaining test points in January and March for the kneeling medicine ball throw. Athletes significantly took longer to complete a 6-meter single-leg hop over the test points compared to the initial test in October. Multiple isokinetic outcomes at all three speeds significantly decreased at the testing time points.

CONCLUSION

Overall, this study determined that conducting field and isokinetic testing throughout the season can monitor the onset of fatigue by detecting decreases in testing measures. Using a combination of medicine ball throws, hop testing, and isokinetic testing at specific times during a season may provide insight into the overall fatigue level and injury risk within baseball pitchers. Routine monitoring of non-pitching-related testing measures is warranted and may add to the evidence to either rest the athlete or intervene with preventative treatment.

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