THE EFFECT OF YOGA ON PITCHER RECOVERY FOLLOWING IN-GAME THROWING. A PILOT STUDY

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INTRODUCTION: Understanding the risk factors associated with pitching-related injuries and interventions to reduce risk is a highly sought-after research topic. For decades, biomechanics labs have tested pitchers with marker-based motion capture, in hopes of uncovering a predictive measure of increased risk. While no studies have yet found that relationship, there has been a lot of forward progress in the realm of understanding the relationship between range-of-motion, strength, workload, and fatigue on pitcher injury risk.

Reinold et al, noted a significant decrease in dominant shoulder passive range-of-motion (ROM) immediately after baseball pitching.¹ Additionally, Camp et al found that passive hip ROM had significant changes over a season, and that there was a significant relationship between shoulder ROM deficits and injury risk in professional baseball players.², ³ This was further corroborated by Wilk et al, who found significant relationships between bilateral shoulder ROM deficits (GIRD) and injury risk.⁴

Other studies have investigated shoulder ROM and cross-sectional-area (CSA) inflammation of the rotator cuff muscles before and after pitching. Yanigaisawa et al found that pitchers experienced a significant decline in shoulder ROM 24 hours after pitching, and significant increase in CSA 24 hours after pitching.⁵ Pexa et al expanded this work, by repeatedly testing CSA for four days after a bout of in-game pitching. Their work found that CSA recovered within 2 days following pitching in a group of 10 collegiate pitchers.⁶

In addition to ROM deficits occurring after intense physical activity, strength dynamics are also key variables in understanding the risk factors for pitching-related injuries. Newham et al found that intense bouts of eccentric biceps muscle activity reduced strength by approximately 50% on the day after exposure. Furthermore, they noted increased recovery rates after repeated exposures during a six-week study period.⁷ More specific to baseball pitchers, Mullaney et al found a significant decline in shoulder strength after in-game pitching via hand-held dynamometers. They noted the involved shoulder lost 11-18% of muscle strength compared to the contralateral side.⁸

Understanding these benchmarks of ROM and strength recovery rates is extremely important for practitioners to evaluate the effects of recovery interventions. Bishop et al evaluated the effect of intermittent arm and shoulder cooling in baseball pitchers, and found significant effects of the intervention on recovery rates, albeit on the scale of hours.⁹ Warren et al performed a similar study that evaluated the effect of various recovery protocols such as electric muscle simulation on ROM and lactate levels. However, this study was also limited to evaluating these intervention’s effects on the day of pitching only.¹⁰

Beyond understanding standard recovery rates from fatigue, there are also mechanisms of fitness that are at play. Starting with the work from Newham et al, who found a marked improvement of recovery rates over a 6 week training program⁷, emerging measures of acute and chronic workloads offer additional insight. Defined as a 28-day average of gross body workload, Bowen et al found that the lowest non-contact injury risk occurred when chronic workload was the lowest. Their work also noted increased injury risk when acute workload (7 day average of gross body workload) exceeded chronic workload by a factor.
of 2. This is often referred to as the acute:chronic ratio (ACR). Specific to the sport of baseball, Mehta et al corroborated the work from Bowen and others, finding a significant logistic relationship between elevated ACR and injury risk.\textsuperscript{11} To this end, ACR is a measure of pitcher fatigue, and fatigue has been strongly linked to pitcher injury risk. Olsen et al found that self-reported throwing while fatigued resulted in a 36 times increase in injury risk. This is further compared to their overuse findings, which found that throwing more than 100 innings in a calendar year resulted in a 3.5 times increase in risk.\textsuperscript{12} This ten-fold increase in magnitude supports that throwing while fatigued is much more strongly linked to injury risk than traditional overuse concepts.

While there is a lack of literature on the acute recovery patterns from fatigue in baseball pitchers, there is also a lack of literature that investigates the effect of recovery interventions on the scale of days. The leading work to this point has been established by Yanagisawa et al, who found that light shoulder exercise and ice treatment significantly improved CSA and ROM 24 hours after pitching.

Yoga has reportedly become a more popular intervention strategy for baseball players at all levels. However, there is a lack of evidence on the efficacy of yoga-based therapies and its effect on reduction of injury risk. Sorbe et al evaluated the effect of a 6-week yoga program on golf swing mechanics, and note significant improvements in the “x-factor” or trunk separation during the swing. This suggests a relationship between long term ROM adaptations and yoga therapies.\textsuperscript{13} Poslgrove et al found that over a 10 week yoga practice, college athletes gained more flexibility, adding to the long term adaptions that yoga can influence.\textsuperscript{14} Lastly, McLean et al investigated the effect of a 12 week yoga practice on physical characteristics of college baseball players, noting significant improvement in shoulder and hamstring flexibility.\textsuperscript{15}

Despite the evidence for reduction in ROM and strength after in-game pitching, and despite the evidence of the effect of yoga on ROM, no studies have analyzed acute recovery rates amongst control and test groups in baseball pitchers during physiologically relevant time scales. Furthermore, there is a lack of literature that investigates the effect of fitness and strength levels on recovery patterns. The primary aim of this study is to quantify ROM and strength recovery rates in baseball pitchers. Additionally, this study aims to investigate the effect of yoga on acute ROM and strength changes.

**METHODS:** Ten healthy male baseball pitchers (aged 16.1 +/- 1.7 years) were recruited for this study. Each pitcher was randomly assigned to a control group or a test group. The test group received two athlete-specific yoga classes in the days following a bout of competitive in-game pitching, including a 60 minute recovery-themed yoga class the day after pitching and a 60-minute vinyasa-themed yoga class two days after pitching.

The recovery-themed yoga class focused on passive/supported supine stretches and breathing techniques. Yoga therapy balls were used for self-myofascial release. The vinyasa-themed yoga class included more movement focusing on active stretches and moving with breath. Both yoga classes ended with a down regulation of the nervous system using aromatherapy, music, and sensory deprivation followed by a short period of mindfulness.

Each participant underwent biomechanical analysis at baseline (the day before pitching in game), and daily for four days following in-game pitching. Biomechanical analyses included iso-metric shoulder strength examination with a band-mounted force sensor (KineticPro, Tampa, FL), vertical jump examination with a waistband-mounted inertial measurement unit (IMU) (Motus Global, Rockville Centre
NY) and active shoulder, spine, and hip range-of-motion examination with six skin-mounted IMU’s (Motus Global, Rockville Centre NY).

All biomechanical analyses were administered prior to any athletic activity on each day and before any athletic warmup routine. The test group received a second biomechanical analysis after each yoga class.

The iso-metric shoulder strength examination measured external and internal shoulder rotation force output while the shoulder was abducted to zero degrees and externally rotated zero degrees. Each athlete conducted three maximal effort trials. The vertical-jump examination measured peak jump velocity and jump force during a countermovement jump. Each athlete conducted three maximal effort trials.

The range-of-motion examination measured the following peak active joint angles on the dominant and non-dominant limbs: shoulder external rotation, shoulder internal rotation, shoulder abduction while internally rotated, shoulder extension, thoracic rotation, thoracic lateral flexion, hip external rotation, hip internal rotation, and hip abduction. The range-of-motion examination also measured peak trunk flexion, peak trunk extension, peak pelvis flexion, static trunk flexion, and static pelvis flexion. Static posture measures were gathered during a sensor-calibration movement while the subject stood in a standing position with the shoulders abducted 90 degrees, shoulders externally rotated to 0 degrees, and with the elbows bent to 90 degrees.

Biomechanical data were mined, transformed to a dominant limb when applicable, segmented by day, and statistically analyzed in Matlab 2017A (Mathworks, Natick, MA). Multiple-analysis-of-variance and logistic regression were computed for all independent variables (days since competition and test group) and dependent variables (percent maximum and absolute value of all 28 test measures). Post-hoc t-tests were computed for all between-group measures and were tested with a significance level of p<0.05.

**RESULTS**: The output of the MANOVA for each variable are summarized in Table 1. Of all 28 variables investigated, 11 showed a significant relationship between day from baseline and percent maximum of the variable over the span of testing: static trunk flexion, dominant shoulder abduction, non-dominant shoulder abduction, dominant shoulder extension, non-dominant shoulder extension, dominant shoulder external rotation, dominant shoulder internal rotation, non-dominant shoulder external rotation, non-dominant shoulder internal rotation, shoulder external rotation force.

In the day following a bout of pitching, each of the 11 significant “by-day” variables exhibited a decline in magnitude of mobility, force, or velocity. As well, each of the 11 significant “by-day” variables increased in magnitude as the length of time from in-game pitching increased.
Table 1 – Summarized MANOVA results between day and magnitude of force, velocity, or mobility. There were no significant differences between dates except between A) days 1-2, B) days 1-3, C) days 1-4, D) days 2-3, E) days 2-4, and F) days 3-4

The post-hoc t-tests of the 11 “by-day” variables exhibiting model significance show various rates of magnitude recovery by day. Range of motion reached the highest magnitude in the following number of days after pitching, in the following variables: static trunk flexion posture (3 days) dominant shoulder abduction (4 days), non-dominant shoulder abduction (2 days), dominant shoulder extension (4 days), non-dominant shoulder extension (3 days), dominant shoulder internal rotation (2 days), dominant shoulder external rotation (3 days), non-dominant shoulder internal rotation (2 days), shoulder internal rotation force (3 days), shoulder external rotation force (2 days).
Figure 1a – Range of motion as percent of maximum within a five day span, for significant shoulder variables.
Figure 1b - Range of motion as percent of maximum within a five day span, for significant shoulder variables.
Figure 1c - Range of motion as percent of maximum within a five day span, for significant shoulder variables.

The by-group output of the MANOVA indicated that test group had an effect of four variables: non-dominant hip external rotation, non-dominant shoulder abduction, dominant shoulder internal rotation, and dominant trunk lateral tilt for absolute range-of-motion angles.

The group who received yoga treatment achieved significantly greater non-dominant shoulder abduction on 3 days after pitching in-game. The yoga group also achieved significantly greater non-dominant hip external rotation 2 days after pitching in-game. While not significant, the yoga group achieved greater dominant trunk lateral tilt and greater dominant shoulder internal rotation on each of the 4 days of testing following a bout of in-game pitching.
For each athlete that received a yoga class (n = 5), their assessments were conducted before and after their two yoga classes. A percent difference between the pre-yoga and post-yoga biomechanical assessments were computed for all 28 variables. A series of paired t-tests revealed that four variables achieved significant improvements after yoga (p<0.05): max pelvis flexion, non-dominant shoulder abduction, non-dominant shoulder internal rotation, and dominant trunk rotation. Two variables showed near-significance in improvements: non-dominant hip external rotation and static jump velocity. While not significant, 22 measures achieved net-positive improvements in mobility, force, and velocity. Two variables that achieved net-negative decline in mobility were max trunk extension and dominant shoulder extension, but they were not significant (p > 0.05).
DISCUSSION & CONCLUSION: Upon analysis of the effect that days since pitching has on range-of-motion, 11 variables emerged as potential indicators of fatigue. Most notably, dominant and non-dominant shoulder abduction experienced severe decline in magnitude following in-game pitching. In each of the 11 variables that showed an effect of days since pitching, the magnitude of range-of-motion increased as the duration of time increased. This increase in mobility may correlate with athlete recovery from inflammation and soreness, and is desirable prior to the next successive bout of pitching.

Speeding the recovery process is a highly sought after ability. Upon analysis of the effect that yoga had on range of motion throughout the testing period, 4 variables emerged as potentially effected by yoga. Pitchers in the yoga group achieved significantly better non-dominant hip external rotation and non-dominant shoulder abduction sooner than the control group. This suggests that yoga can help speed up the recovery time of some fatigue markers.

On a more acute time-frame, pre and post yoga assessments showed that after a yoga class, pitchers achieved significantly more pelvis flexion, non-dominant shoulder abduction, non-dominant shoulder internal rotation, and dominant trunk rotation. Of all 28 variables analyzed, and while not statistically significant, 22 measures achieved net-positive improvements. While these acute changes immediately after yoga did not necessarily lead to longer term adaptations, their effect on the day of training may aide in the recovery process and minimize exposure to fatigue within a single day.

Overall, yoga helps to moderately improve range-of-motion in baseball pitchers in planes of motion that are desirable to the needs of the sport. Furthermore, yoga speeds the recovery process of key fatigue markers, and may offer more physical benefits than has previously been considered.
REFERENCES:


