

# THE RELATIONSHIP BETWEEN THROWING INJURY AND ACUTE:CHRONIC VALGUS WORKLOAD RATIO IN HIGH SCHOOL BASEBALL PLAYERS

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## INTRODUCTION

Documenting workloads in athletes has become a vital component in training and competition in numerous team sports. In baseball, specifically, workload has been monitored in multiple ways: number of pitches thrown in a game, pitches thrown in a season, total innings pitched, and even ball velocity. In youth baseball pitchers, research has shown that increased workload (pitching over 100 innings in a calendar year) increases the likelihood of injury.<sup>1</sup> Lyman et al<sup>4</sup> reported a positive association between pitching load and elbow pain. While positive associations have been made between these workload metrics and injury there lacks evidence establishing a direct relationship between the two. More recently the use of wearable sensors has given teams the ability to track and monitor athletes' workloads for the day, week, and season. In rugby players, GPS tracking of full body workload (distance covered during all training) has shown that high chronic workload (four week average of workload) may decrease injury risk and high acute:chronic workload ratios may increase injury risk.<sup>3</sup> Using GPS in cricket players, Hulin<sup>2</sup> reported that fast bowlers who had 200% greater acute workload to chronic workload were 3.3 times more likely to get injured compared to bowlers who were under 100%. Despite the significant relationships found between workload and injury, no research has investigated the specific effects of acute and chronic workloads in baseball pitchers to injury.

The motusBASEBALL™ sensor is an inertial measurement unit that monitors elbow valgus torque during a throw. When worn for extended periods of time, the technology allows for measurement of cumulative workload on the throwing arm. This paper pairs cumulative workload data collected over a six-month period with upper-body injury outcomes. It is the first

analysis of the relationship between acute-to-chronic valgus workload ratio (ACVR) and injury.

## METHODS

Eighteen male baseball players (aged 17.0 ±0.7 year, height 185 ±5.7 cm, and weight 85.2 ±7.6 kg), competing at the varsity level wore the motusTHROW™ compression sleeve and sensor during pre-season training and the regular 2017 high school season. Of the eighteen athletes, four athletes were non-pitchers and the remaining fourteen threw in at least one game inning. Sleeves were worn every day that throwing activity took place, including practice and games. For each throw, the sensor recorded arm slot (°), arm speed (°/s), maximum shoulder external rotation (°), and peak elbow valgus torque (Nm). At the end of the season, all throwing related injuries were reported and the associated injury date was noted. Over 159 days of throwing, a total of 171,703 throws were captured with the motusTHROW™ sensors.

Binary logistic regression was utilized to estimate the effect of ACVR on injury occurrence. A relative risk ratio was calculated to compare injury risk between low ACVR and high ACVR groups.

## RESULTS AND DISCUSSION

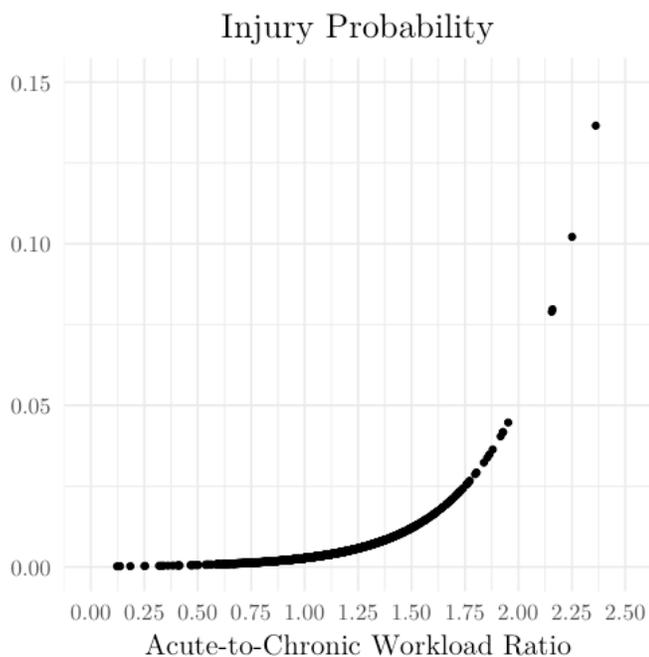
Overall there were a total of eight throwing-related injuries recorded through the 2017 season. Seven of the eight throwing-related injuries occurred when athletes had an ACVR greater than 1.3, which marks the 80<sup>th</sup> percentile across all observations. This suggests that athletes may be at higher risk of injury at higher ACVRs.

A cutoff ACVR of 1.3 was used to calculate a risk ratio and results are reported in Table 1. This risk ratio suggests that athletes with an ACVR above 1.3 were 26 times more likely to sustain an upper-body injury.

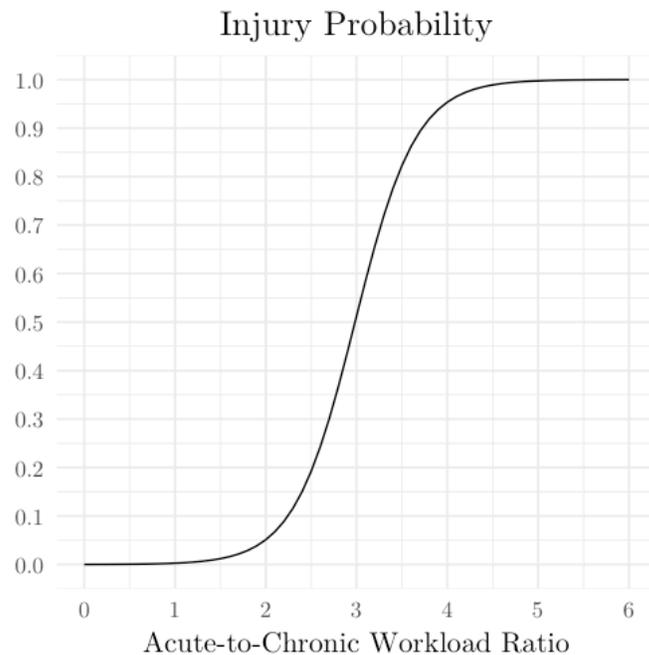
Injury Risk & ACVR	
ACVR < 1.3	ACVR > 1.3
0.084%	2.19%

**Table 1.** Injury incidence above and below 80<sup>th</sup> percentile ACVR (1.3)

Furthermore, results of logistic regression (Figure 1) suggested that ACVR is significantly related to injury occurrence ( $p < 0.01$ ). This further corroborates the idea that a high acute workload relative to chronic workload can place an athlete at an increased risk of injury. Based on this data a cumulative probability relationship of ACVR and throwing arm injury was generated and is presented in Figure 2.



**Figure 1.** Logistic regression predicted probabilities



**Figure 2.** Cumulative Probability relationship between ACVR and throwing arm injury.

## CONCLUSION

Logistic regression and the accompanying risk ratio suggest that there is a significant relationship between ACVR and injury occurrence such that high ACVRs may increase injury risk.

Throwers should avoid dramatic increases in acute workload to their throwing arm. In situations where this cannot be avoided, throwers should exercise great caution when throwing on days where their ACVR is elevated. On these days, recovery interventions should be reinforced and a pitcher should avoid throwing to fatigue.

These findings also support the use of load engineering, under which valgus load can be calculated and prescribed on a daily basis to prevent the ACVR from reaching levels that may increase injury risk.

## REFERENCES

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