A NOVEL METHOD FOR DETERMINATION OF CUMULATIVE WORKLOAD FOR BASEBALL PITCHERS

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INTRODUCTION

Training load has proven to be a modifiable risk factor for injury[2] and several studies have investigated the relationship of training workload and injury risk in athletes. Previous research on workload in baseball pitchers focuses on season totals and games pitched, total innings pitched, and total pitches thrown.[7-9] This type of monitoring is crude as it assumes all pitches cause an equivalent amount of stress and neglects all other throws made during a season (i.e. warm-up, catch, long -toss, bull pen, etc). Additionally, these commonly used workload monitoring tools for throwing sports lack reliability and validity and are not capable of monitoring all aspects of training and competition. Global positioning systems (GPS) and inertial measurement units (IMUs) have recently been used to monitor athlete's movements and have been shown to be an accurate and reliable method of monitoring workloads.[3] A single sensor IMU has been developed to provide real time metrics, most importantly elbow varus torque, which allows each throw to be monitored and a specific workload profile to be created for each pitcher. These sensors provide the ability to monitor joint specific workload based on 'acute:chronic' workload ratios (A:C), which are popular in other sports such as rugby, soccer, and cricket. These ratios have been suggested to indicate an athlete's risk of injury and preparedness to perform.[5] Studies have reported high chronic workloads were associated with reduced risk of injury and spikes in acute workload compared to chronic were associated with increased risk in injury.[6,10-11] However, no research has been done on A:C workload in baseball pitchers. Therefore, the purpose of this study was to examine joint specific A:C ratios in baseball pitchers and to present a new way of measuring workload in baseball pitchers using the motusBASEBALL™ sensor (Motus Global, Rockville Centre, NY).

METHODS

A professional baseball pitcher (age 20 years; 95 ± 10 kg; and 190 ± 6 cm) was recruited to wear a motusBASEBALL™ sensor every day throughout the Minor League 2016 season. For each throw, the sensor recorded arm slot (°), arm angular velocity (°/s), maximum shoulder external rotation (ER) (°), and elbow varus torque (Nm). Workload was measured as a cumulative varus torque on the throwing elbow. Acute workload is a rolling 7-day average of daily workload and chronic is a rolling 28-day average of workload. The A:C workload ratio is the acute workload divided by the chronic workload. Injury was reported by the team athletic trainer and was defined as any time loss from practice or competition.

$$Daily\ Workload\ = \sum_{throw=1}^{throw=n} \frac{Valgus\ Torque\ [Nm]^{1.3}}{height * weight}$$

$$Acute\ Workload\ = \frac{1}{7} \sum_{day=today-6}^{day=today} Daily\ Workload$$

$$Chronic\ Workload\ = \frac{1}{28} \sum_{day=today-27}^{day=today} Daily\ Workload$$

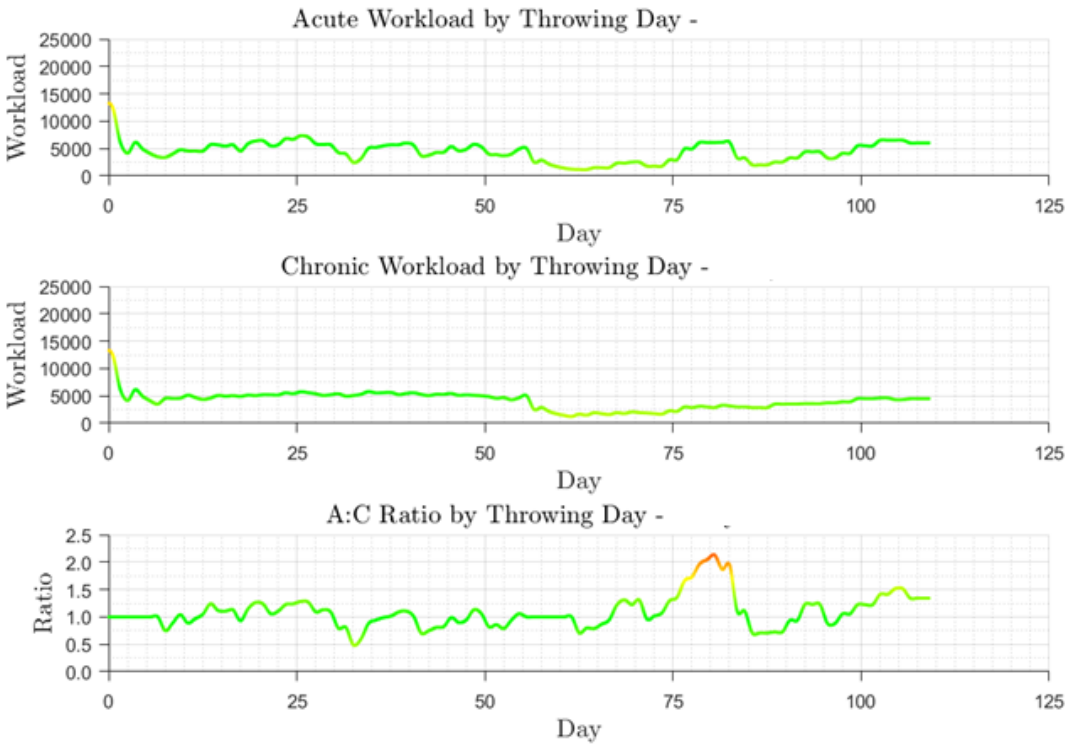

Figure 1. Player workloads by throwing day. Green line represents an Acute:Chronic workload ratio that was within 1 standard deviation of the average. Yellow represents the ratio was between 1 and 1.5 and red represents the ratio 2 standard deviations from the average. Note: On day 80 there was a large peak in A:C ratio (2.2) and this is where the player sustained an elbow injury.

RESULTS AND DISCUSSION

Over the course of 110 days, the player had an average acute workload of 7352 Nm and an average chronic workload of 5766 Nm. The player maintained a A:C workload with in one standard deviation of 1.0 until day 76, where the ratio peaked at 2.1 An A:C workload of ≥ 1.5 has been associated with large increases in injury risk.[1,6] In the current study, we found the player sustained an ulnar collateral sprain when had a A:C ratio of 2.1. This means that the player increased his workload in the given week by 210% compared to his previous month. Monitoring these spikes in workloads and adjusting throwing volumes accordingly can potentially help coaches and trainers guide their players' workload to avoid peak injury risk scenarios.

Monitoring daily workload allows for a more appropriate measure compared to throw count, timed throwing, and bull pen and game throwing count workloads. Daily workload takes into account the varus torque of every throw made, which can vary significantly within and across players. Understanding how an individual athlete responds to the demand of training and competition is vital.

It has been suggested that reducing workloads may minimize the risk of injury; however, reducing workloads in training and competition has also been considered detrimental to an athlete's conditioning and performance.[4] Training for sports requires a balance of appropriate training loads to develop the physical qualities to compete and allowing appropriate time to recover between sessions.[10] The full body A:C workload has been associated with increases in performance in individual and team sports; however, future research needs to examine joint specific acute, chronic, and A:C workload ratios and performance in pitchers.

CONCLUSION

Workload in baseball has been limited to simple measures such as pitch count; however, advancements in technology have allowed for the use of IMUs to detect every throw and provide measures to more specifically account for workloads. This is the first investigation of joint specific acute, chronic, and A:C workloads in a baseball player with the use of an IMU. We also found that a spike in acute workload increases risk of injury. Monitoring these changes in workload can potentially raise awareness for injury risk changes during a season. Wearing the motusBASEBALL sensor every day to track every throw allowed for the ability to monitor joint specific workloads; however, future studies with more athletes need to be conducted to better understand the relationship between changes in the A:C workload ratio and injury risk.

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