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Letter to the Editor

Author Response - Letter to the Editor Concerning: "An Interval Throwing Program for Baseball Pitchers Based upon Workload Data"

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We have received the letter to the editor by Wong, Evans, and Meister and appreciate the authors' interest in our manuscript "An Interval Throwing Program for Baseball Pitchers Based upon Workload Data." Thank you for the opportunity to respond. In their letter, Wong et al. made several statements that we find are not supported by science and may be misleading to the reader. The letter states that Reinold et al.[1] "utilized an unvalidated inertial measurement unit (IMU) device" because "multiple scientific studies"[2-4] have "clearly demonstrated that this particular IMU device is not valid for accurately measuring elbow arm stress." The letter points out that elbow torque magnitudes from the IMU sensor reported by Reinold et al.[1] are significantly less than torque magnitudes reported by "gold standard" motion capture systems. In summary, they state elbow torque magnitudes are different when measured with IMU than when measured with camera-based motion capture, and therefore IMU data are wrong.

We agree that elbow throwing torque magnitudes reported in Reinold et al.[1] and nearly two dozen other peer-reviewed studies[2,3,5-21] using the IMU are consistently less than elbow torque magnitudes reported by camera-based motion capture studies. However, we challenge the letter's implication that differences between the two technologies show that motion capture data are correct and IMU data are incorrect. The technologies are different and utilize different capture rates as well as models to build kinematics and kinetics, so naturally there will be variation in values measured. This also happens when comparing camera-based motion capture studies from different labs all the time, as well as between marker-based and markerless motion capture systems.[22] It is important for the reader to understand that elbow torque magnitudes are different when comparing between methods, however produce similar patterns that are reliable.

Of the three "scientific studies" cited in the letter, one was simply a letter and not a peer-reviewed study.[4] The two actual peer-reviewed validity studies showed significant differences ("inaccuracy") between the IMU and motion capture but conclude that data were consistent within the IMU ("reliable").[2,3] Wong et al, in their letter, incorrectly stated that the Camp et al paper found the "IMU reliably produces untrustworthy numbers within the same subject". While in fact, Camp et al specifically stated "intrathrower reliability was not formally assessed."[3] Furthermore, both validation studies showed that elbow torque from IMU correlated with elbow torque from motion capture. Motion capture may be viewed as the "gold standard" in throwing biomechanics because it has been used in published studies for decades (including many times by us), but the newer IMU technology also produces reliable data that can be used to develop interval throwing programs.

The biomechanical model developed in Dowling et al.[5] and used in Reinold et al.[1] calculates workload based upon within-subject changes in elbow torque for different types of throws. Because IMU and motion capture data are correlated, the chronic workload graphs for the interval throwing programs presented in these studies would likely be remarkably similar to what is shown even if motion capture data had been used; simply, the magnitude of chronic workload would be on a different scale. Acute:chronic workload ratios likely would not change.

The authors of the letter explained difficulties they had in the past with their past experience using the IMU, which may be the basis for their biased feelings that any research using data from this IMU is inaccurate and invalid. We acknowledge that they had difficulty with this IMU and respect their decision to continue their rehabilitation protocols without using biomechanical data. However, their implication that data in the current study were unreliable because no one was monitoring the throwing with the IMU is absolutely incorrect. One of our researchers (B. Dowling) was in charge of the original data collection and was part of a team that, in fact, did stand with players during throwing activities to monitor the throwing and tag the distance for every throw made. During this collection, researchers instructed players to check and ensure their sleeve did not move throughout each throwing session. Properly fitted sleeves did not move and this was not a substantial issue with each throwing session. In retrospect, we acknowledge it may have been helpful for us to include these details in the methods of our papers.

Another point of consideration is that intensity is only part of the equation of workload modeling, along with volume and frequency. While there are other methods of measuring intensity in addition to torque, such as distance, perceived effort, and velocity measured by radar as the letter authors mention, until these methods are studied it is our recommendation to utilize torque. Regardless, considering the program (and all other interval throwing programs)

uses partial effort throws to build up volume on flat ground, intensity is likely not the most significant factor in workload modeling when compared to volume and frequency.

When formulating the interval throwing program in our paper[1] and Dowling's previous paper,[5] what we actually found was that past programs did a generally acceptable job of progressing workload. But by strategically manipulating the volume and frequency, we were able to formulate a more optimized progression that we feel will be much better tolerated by the patient and help them return to sport safer and more effectively. This is the novel approach that we feel makes our throwing program optimal.

It is our belief that any interval throwing program should utilize the most current evidence in regard to biomechanics and workload monitoring. While there may be multiple ways to quantify intensity, using an interval throwing program that does not consider workload is shortsighted. As explained in our study and furthermore in this response, the updated interval throwing program presented in Reinold et al.[1] is based upon reliable biomechanical data and workload management to safely and efficiently rehabilitate pitchers back to pitching after shoulder and elbow injuries.

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