Using Wearable Technology to Evaluate the Kinetics and Kinematics of the Overhead Throwing Motion in Baseball Players

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Abstract: Recent advancements in wearable technology have made kinetic and kinematic analysis of the throwing motion more accessible to recreational and professional baseball pitchers. Utilization of wearable technology to monitor the pitching motion has several potential applications for injury prevention and postinjury rehabilitation. However, the device must be properly applied to collect meaningful data. Erratic or inconsistent measurements can be caused by inadequate battery charge, incorrect sensor placement, and inadvertent motion capture of fielding maneuvers or other nonpitching throws. These problems can be overcome with a protocol that includes collecting biomechanical data in real time and routinely checking the sensor position throughout the duration of the throwing session. In this article, we outline our protocol for collecting biomechanical data and troubleshooting suboptimal device function during pitching sessions.

Recent advancements in wearable technology have made kinetic and kinematic analysis of the throwing motion more accessible to recreational and professional baseball pitchers. Until recently, evaluation of the throwing motion has required high-speed motion capture that uses markers to track motion in 3 dimensions; however, this technology is expensive, cumbersome, and often requires a controlled laboratory setting. New wearable technology is relatively inexpensive and can be used in the field setting, allowing for pitchers to track their motion and elbow torque during practice and competition (Table 1).

Utilization of inexpensive, wearable technology to monitor the pitching motion has several potential applications for injury prevention and postinjury rehabilitation. However, the device must be properly applied to collect meaningful data (Table 2). Therefore, the purpose of this technique guide is to review our method of using wearable technology to consistently evaluate the throwing motion in baseball pitchers. We outline our protocol for collecting biomechanical data and discuss our methods for troubleshooting suboptimal device function during pitching sessions (Video 1).

Technique

Data Collection Protocol

Pitchers are asked to throw from a mound at a distance of 18.4 m from home plate (or at the appropriate distance for their age group). If a catcher is available, we will have them participate to better simulate competitive play. A researcher stands directly behind the pitcher and aims the radar gun toward home plate for greatest accuracy of ball speed (Fig 1). If the sensor is being used to measure the throwing motion during a long-toss program, participants will throw from flat ground and the researchers will constantly reposition themselves behind the thrower to maintain the accuracy of the radar gun. This baseline setup is the same regardless of whether data collection takes place on the field or in a pitching tunnel.

Our research group uses a sensor from MotusBaseball (Motus Global, Rockville Centre, NY) in studies involving wearable technology. The sensor has a gyrometer and accelerometer that allows it to measure various
parameters of throwing motion, including medial elbow torque, arm slow, arm speed, and shoulder rotation. These measurements are transmitted via Bluetooth technology to a mobile phone application (motusTHROW, v.8.6.3, Motus Global) (Fig 2).

An elastic athletic sleeve has a pocket for the sensor and is used to position the sensor on the arm. We allow pitchers to select the size sleeve they deem most comfortable to avoid impeding their natural throwing motion. We position the sensor per the manufacturer’s instructions; that is, 1.5 inches (or roughly 2 finger-breadths) distal to the medial epicondyle of the humerus (Fig 3).

During the throwing session, we use the “Live Mode” function of the phone application to obtain real-time biomechanical data following each pitch. The researcher standing behind the pitcher reviews the measurements from the phone application and manually records the data from each pitch onto a spreadsheet using a laptop computer in real time. This process is repeated throughout the duration of the throwing session.

Troubleshooting

There are a number of factors that may cause erratic or inconsistent measurements when using wearable technology to measure various aspects of the throwing motion.

Table 1. Advantages and Disadvantages of Wearable Technology

| Advantages | Disadvantages |
|------------|---------------|
| Wearable devices are less expensive and cumbersome when compared with traditional high-speed motion capture analysis | Distance between the sensor and mobile phone may be a limiting factor in use during live competition |
| Kinetic and kinematic analysis can be done outside of the laboratory setting | Accurate and precise data collection depends on meticulous methodological technique |
| Feasibility of longitudinal data collection allows pitchers to assess for changes in pitching mechanics, workload, or postinjury rehabilitation | |

Feasibility of longitudinal data collection allows pitchers to assess for changes in pitching mechanics, workload, or postinjury rehabilitation.

First, it is important that the sensor’s battery is charged immediately before use. When traveling with the device, it is common for the sensor to record sudden
movements as if they were pitches, especially if the device is being swung around in an equipment bag. These recordings can drain the sensor’s battery before the throwing session. For this reason, we always use our laptop to charge the sensor immediately before use.

Because the sensor indiscriminately registers any sudden movement of the arm as a pitch, errant recordings can occur during bullpen sessions and competitive play as well. For example, warmup throws, throws to first base, or even throwing a baseball or rosin bag to the ground may record alongside actual full-effort pitches. Although the mobile app makes it possible to retrospectively review the recorded data, these erroneous recordings make it extremely difficult to correlate the biomechanical data with each pitch. Our method of manually inputting the biomechanical data 1 pitch at a time gives us confidence that we are measuring the intended throws. This also provides us the opportunity to identify inconsistent measurements and rectify those issues in real time.

Last, the reliability of the device almost entirely hinges on the consistency of the sensor location on the elbow. In our experience, pitchers generally prefer the sleeve to be slightly loose; this predisposes them to having the sleeve slide down the arm after a few pitches, which negatively affects the reliability and accuracy of the sensor. We routinely check the position of the sensor every 3 to 4 pitches to ensure its correct placement on the elbow.

**Discussion**

Wearable technology has emerged as a practical alternative to high-speed motion analysis for evaluation of the throwing motion. Although this technology presents challenges associated with consistent measurements and data collection, the described protocol can be used to overcome these challenges, particularly for research applications.

The sensor used in our studies has been validated against the gold-standard high-speed motion analysis and found to be reliable for adolescent, collegiate, and professional athletes. We have used this sensor in several recent studies to evaluate the biomechanical parameters associated with pitch type, fatigue, ball weight, glenohumeral internal rotation deficit, and partial effort pitching.

We have yet to use wearable technology to study biomechanical parameters during active competition. This is due to one of the major limitations of our protocol; that is, to use the Live Mode function of the mobile application, the researcher’s phone must be in close proximity to the sensor for transmission of data in real time via Bluetooth. Although this is not an issue during bullpen sessions or the practice setting, the sensor does not always reliably transmit data from the mound to the dugout, making it difficult to use this method of data collection during active competition. Future investigation of wearable technology during active competition would help us understand how the throwing motion changes throughout a game and could eventually be used for injury prevention.

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