Examining the potential for Doppler-radar pitch kinematics measurements to act as an indicator of susceptibility to injury in youth baseball pitchers

SPECIFIC AIMS

1. Establish baseline values for pitch speed, spin and tilt of fastballs and curveballs in an in-game situation in high school pitchers.
2. Compare the pitch kinematics in youth baseball pitchers in in-game and non-game situations.
3. Attempt to correlate spin and tilt of curveballs to pain in the high school pitcher.

SIGNIFICANCE

Despite a steady (~3% year-to-year) decline in participation in the last decade, an estimated 5 million youth aged 7-17 will participate in organized baseball in 2016 [1]. Concurrently, the incidence of injury serious enough that the youth must stop playing has increased to 5%. Youth are at particular risk because their muscles and skeletons are immature and susceptible to the development of structural deformities. Among pitchers, injuries are most often to the elbow and shoulder. Various studies have been conducted to identify factors that increase youth pitchers' risk of serious injury. These studies are generally either epidemiological or biomechanical in nature. The epidemiological studies focus on factors such as pitch count, rest intervals, and pitch type—specifically the curveball.

The utility of the curveball is in the "sink" or curve that gives it its name. While an ideal fastball falls, over the course of the 60 feet 6 inches from the pitching rubber to the plate, less than gravity would account for, the curveball curves substantially more than gravity accounts for. The force responsible for both of these types of movement is called the Magnus force. In the case of the fastball, this force points up, causing lift, and in the case of the curveball, it points down, causing sink. The Magnus force is a result of the fluid dynamics of the ball's spin relative to its trajectory: the direction of the Magnus force can be found by taking the cross product of the angular momentum vector and the velocity vector. A ball thrown with backspin will have an angular momentum vector pointing to the pitcher's right and an upward Magnus force. To produce a downward Magnus force thus requires throwing the ball with topspin.

Baseball pitches are thrown overhand, and the motion of the overhand throw tends to create backspin (the top of the ball rotates toward the pitcher). In order to impart topspin to a ball and produce a curveball, the fingers must pull over the front of the ball, which requires a particular turn of the wrist (supination). It has long been assumed that this "unnatural" motion produces significantly more strain on the wrist, elbow and shoulder than the "natural" motion of the fastball. Several biomechanical-type studies have attempted to quantify this. Nissen *et al.* specifically compared the mechanics of curveballs and fastballs in adolescent pitchers. The study measured four parameters and found that in all but one of these, wrist ulnar moment, joint torque was larger (and therefore presumed more dangerous) when throwing the fastball [2]. A similar study by Dun *et al.* came to a similar conclusion [3].

Among the epidemiological studies, Lyman *et al.* found that the slider is the pitch most associated with elbow pain among youth, but that the curveball increases the risk of shoulder pain [4]. A recent (2015) comprehensive literature review by Grantham, *et al* arrives at the conclusion that "biomechanical and most epidemiologic studies do not demonstrate an increased risk of pain and/or injury" when comparing the curveball to the fastball [5]. However, the fear of the curveball is so strong that even studies that are forced to conclude that there is no increased risk recommend against youth throwing the pitch [6]. Others conclude that it is when these pitches are thrown with poor mechanics that youth become susceptible to injury [7]. While studies have shown that there is increased variability among pitching mechanics, as measured by various kinetic and kinematic parameters, at the

youth versus the more advanced level, these same studies establish that the primary difference between the levels is the speed at which the pitch is thrown, not positions, torques or timings [8].

INNOVATION

Contributing to the general lack of evidence regarding whether curveballs are dangerous for youth pitchers is the fact that these biomechanical studies are conducted in a lab setting, without batters or catchers or the excitement of being in a game. Instead, they are in a lab, on a simulated mound, and persistently aware that their mechanics are being watched. The only parameter consistently available to compare the in-game and lab-setting data has been pitch speed which has been shown to average 5-7 mph slower in the lab setting [9]. The difficulty with taking this research out of the lab is that it is generally conducted with an array of high-speed cameras that are unsuitable for the game situation and require the subject to be "marked" with different reflectors. Recently, however, there has been a proliferation of pitch-tracking systems at the professional level and into the college level of baseball. Major League Baseball has used both Pitch f/x, which is a video-based stereoscopic system, and TrackMan, which is a Doppler-radar-based system, for pitch tracking. Neither of these systems can track the biomechanics of the pitcher, as is done in the lab, but it is our Specific Aim to evaluate whether data collected from these systems, in particular, spin data collected via TrackMan, are correlated with pain. Our working hypotheses are that (1) increased spin rate is an indicator of increased wrist flexion torque thus spin rate will be correlated with injury and (2) deviation of the spin axis from the horizontal (tilt) is an indicator of "poor mechanics" thus will be correlated with injury.

APPROACH

A single protocol will suffice for data collection for all three Specific Aims. Data collection for Aims A and C and the "in-game" portion of B will take place concurrently. All pitch data collection will take place at Hunnicutt Field in Princeton, WV. With the permission of the Tampa Bay Rays, whose Appalachian League affiliate, the Princeton Rays, play at the park, data will be collected using their TrackMan system during the 2016 high school baseball season. (After this year, the Rays' lease with Princeton expires and they move their team and their equipment to another venue.) Hunnicutt Field is also the home field of the Princeton High School (PHS) baseball team, so data collection will take place during PHS home games. PHS pitchers and pitchers from the schools they oppose at Hunnicutt are the targeted subject group. Youth who pitch as part of a regularly-scheduled game will be invited back to pitch from the mound in a non-game situation. We are also pursuing developing an "invitational" to provide another opportunity for these players to pitch in front of the system, thus increasing the statistical potency of our data.

Research Population. Approximately 60 male pitchers from both the home and away teams, ranging in age 15 – 18 years old will participate in the study. There will be no selection or exclusion of subjects based on race or ethnic origin. It is anticipated that the sample will reflect the racial and ethnic characteristics of the local community surrounded by the participating site. Subjects must have pitched in at least one organized baseball game during the past year. They must also have parental permission in order to participate.

Pitch Data Pitch data will be collected by the military-grade Doppler radar measuring system, TrackMan. Sampling at a rate of 48,000 measurements per second, the TrackMan system calculates and reports 27 pitch parameters, including the release speed, horizontal and vertical release angles, the spin rate and tilt, release position, horizontal and vertical break, and batter reaction time.

Assessment of Injury. The Disabilities of the Arm, Shoulder, and Hand (DASH) Sports Module and the Upper Extremity Activity Sports Activity Scale will be used to assess arm symptoms and functioning. The DASH Sports Module yields a single score reflecting the degree to which elbow or shoulder problems affect the ability to perform sports activities. Not only does the single reflective score seem convenient, but the DASH has been shown to be effective through reliably and validity tests [10, 11, 12, 13, 14].

Subjects will be asked to perform a preliminary assessment before practice starts in the spring and weekly assessments thereafter.

Analysis. Specific Aim 1: The mean and standard deviation of the pitch speed, spin rate and tilt will be calculated independently for all curveballs and fastballs thrown. Specific Aim 2: Pitch speed, spin rate and tilt data will be compared between the in-game and non-game situations will be compared in aggregate and by individual using a student's t-test. Specific Aim 3: Average spin rate and tilt data will individually be evaluated against the subject's peak DASH score. A Pearson product-moment correlation coefficient will be calculated. A coefficient of 0.3 or greater will be considered a positive result.

Human Subjects Protocol: A human subjects protocol has been designed for this project that is in compliance with Department of Health and Human Services and the Office of Human Subjects Protection guidelines. Data collection on this project would not begin until this plan is approved by the Western Institutional Review Board (WIRB), to whom BSC contracts out IRB services. A significant portion of the funds requested for this project are human subject training and for this plan to be reviewed by WIRB. For this reason, funding of this project would benefit the entire college, not just in the way the entire college is benefitted every time a faculty member starts a research project, but also because this training and the process of obtaining IRB approval for a human subjects protocol would be knowledge and experience that I would transmit to the entire college through my role as the Interim Director of Research and Sponsored Programs.

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POSITIONS AND EMPLOYMENT

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PEER-REVIEWED PUBLICATION AND PATENT CITATIONS (SELECTED)

Measurement of the electron charge asymmetry in $p\bar{p} \rightarrow W + X \rightarrow e\nu + X$ events at $\sqrt{s}$ = 1.96-TeV. DØ Collaboration (V.M. Abazov *et al.*). **Phys.Rev.Lett.101:211801, 2008**.

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RESEARCH SUPPORT

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Development of Office of Sponsored Programs at Bluefield State College
The goal of this project was to build the research infrastructure and grant capacity of Bluefield State College through the establishment of the Office of Sponsored Programs, now called the Office of Research and Sponsored Programs (RASP). Role: PI/EA.