BASEBALL PITCHING TECHNIQUE WITH HEEL OR TOE STRIKE

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An increased concern about throwing arm injuries has prompted biomechanical investigators to examine the mechanics of overarm baseball pitching techniques. A review of the literature reveals that shoulder injuries can be subdivided into two groups: anterior and posterior. Injuries to the anterior shoulder are said to occur during the late cocking and acceleration phases (1,2,4,5,6). Injuries to the posterior shoulder are due to inadequate deceleration of the throwing arm after release (1,3,5,6). Rasch and Burke (1978) speculated that elbow injuries occur medially from traction stresses, laterally from compression of the articular surfaces, and at the posterior aspect due to compression of the olecronon process and olecronon fossa.

A number of techniques have been proposed by coaches and physicians in an attempt to decrease injury causing stresses. Sain and Andrews (1985) stressed the importance of using a "toe-strike" technique of pitching. That is, the initial ground contact with the leading foot should be made with the ball of the foot, rather than with the heel. The latter method is referred to as the "heel-strike" technique. It has been hypothesized that the heel-strike technique causes an abrupt stop or "blocking" of the body that interrupts the smooth transition from the cocking phase to the acceleration phase. It has also been hypothesized that the interruption in the desirable sequence of events in the pitching motion will in some way increase the stresses on vulnerable anatomical structures of the body. However, such injury producing mechanisms have not been precisely identified.

METHODS

Two 16 millimeter cine cameras were positioned with their optical axes forming a horizontal plane and at 90 degrees to one another. One camera faced the pitcher and the other was perpendicular to the line of the throw. A high school varsity pitcher was used for the investigation. The subject normally utilized a "flat-foot" strike technique and it was reasoned that the two unfamiliar pitching styles to be examined would require the subject to make minor adjustments of comparable magnitude. The subject was encouraged to practice the two throwing techniques and after he had indicated that he was comfortable with each of them, filming was initiated. Twenty trials of each foot strike technique were filmed at 200 frames per second. Five representative trials were selected for detailed analysis. Digitization of 19 segment endpoints was carried out using a Graf Pen sonic digitizer (Science Accessory Corporation, Southport, Connecticut) and interfaced with a microcomputer.

Using appropriate software, the mean time histories of linear displacements and linear velocities of the throwing hand, elbow, and shoulder as well as the angular displacements and angular velocities of the knee and shoulders were generated. In addition, the position of the subject's center of gravity in each frame was generated by segmental analysis. Data were acquired from initial foot impact to ball release. The raw data were smoothed using a Fast Fourier Transform. Subsequently, 100 points were generated for each of the smoothed data files using a Cubic Spline interpolation. Critical events were identified for each of the kinematic records and differences between the two throwing techniques were examined using t-tests.

RESULTS

Analysis was designed to permit the examination of three major areas: angular displacements and angular velocities of the knee and ankle joints, linear velocity of the center of gravity and selected velocities of the upper extremities.

Using data obtained from the side-view camera the mean knee joint angle in the sagittal plane at first contact with the ground was 137 degrees for the toe-strike technique and 138 degrees for the heel-strike technique. The minimum knee joint angle for the toe-strike technique was 121 degrees while minimum knee joint angle for the heel-strike technique was 128 degrees.

Although the mean angular velocities in the sagittal plane of the knee joint were quite similar, significant differences were seen just after initial ground contact and at .05 seconds before ball release (Figure 1). Maximum angular velocity of the toe-strike treatment just following initial contact was -260 degrees/second while the corresponding heel-strike angular knee velocity was only -120 degrees/second. The maximum angular knee velocity .05 seconds prior to ball release was -230 degrees/second for toe-strike and -132 degrees/second for heel-strike. Both of these differences were statistically significant ($p < .05$).

The mean angular velocity of the ankle joint in the sagittal plane at initial ground contact was 351 degrees/second for the heel-strike treatment and -120 degrees per/second for the toe-strike treatment. At release, the angular velocity for the heel-strike treatment was 101 degrees/second and -88 degrees/second for the toe-strike treatment.

The mean horizontal, vertical, and medio-lateral velocities of the center of gravity were examined but revealed no significant differences. It is interesting to note that the vertical velocity of the center of gravity at initial ground contact was -1.30 meters/second for the toe-strike trials and -1.60 meters/second for the heel-strike trial. But, .02 seconds after initial contact, the vertical velocity of the heel-strike treatment dropped to -2.0 meters/second while the center of gravity for the toe-strike trial dropped to -1.4 meters/second.

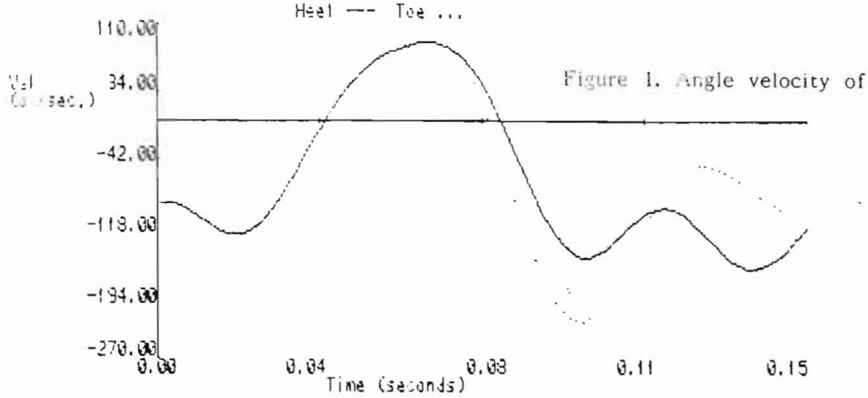

Figure 1. Angle velocity of the knee.

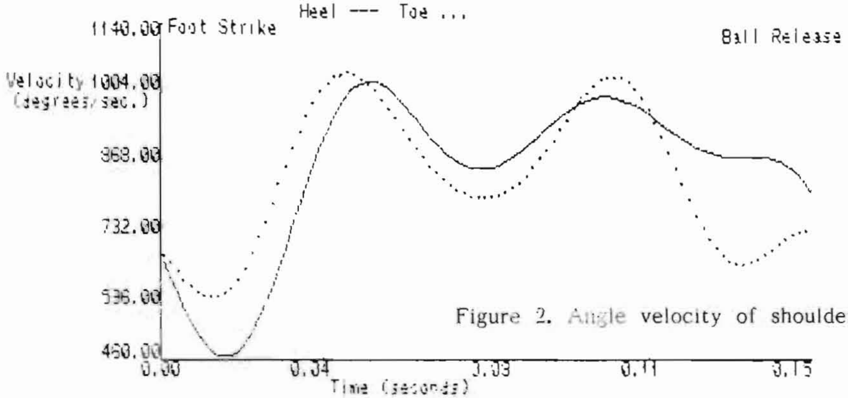

Figure 2. Angle velocity of shoulder rotation

Neither angular velocity of shoulder rotation nor the linear velocities of the hand, elbow, and shoulder of the throwing arm were significantly different. Mean peak angular velocities of shoulder rotation was 1012 degrees/second for the toe-strike trials and 996 degrees/second for the heel-strike trials (Figure 2). Angular velocity of the shoulders at ball release was 764 degrees/second for the heel-strike trials and 703 degrees/second for the toe-strike trials. Mean peak linear velocity of the throwing hand for both treatments was 21 meters/second at .01 seconds before ball release. Peak linear velocity of the elbow for both treatments was 15 meters/second at .05 seconds before ball release and peak linear velocity of the shoulder for both treatments was 7.4 meters/second at .06 seconds before ball release.

DISCUSSION

The significant differences observed in the ankle and knee joint angles and angular velocity of the knee indicates a possible "cushioning effect" at impact for the toe-strike treatment. This cushioning effect could be responsible for a smooth transition of the pitcher's momentum from foot-strike, through acceleration of the throwing arm, to ball release.

The mean horizontal, vertical, and medio-lateral velocities of the centers of gravity were not significantly different. Contrary to what others have hypothesized, there was not an abrupt change in the horizontal or vertical centers of gravity.

With the exception of a few minor differences, the angular velocities of shoulder rotation and the linear velocities of the hand, elbow, and shoulder of the throwing arm were similar. The theory that heel-strike causes premature rotation of the shoulders was not evident. The similarities in the data between treatments showed that no matter which of the two foot strike techniques were employed, "normal" arm motion was exhibited.

CONCLUSION

Based upon findings of this single-subject design and limited number of trials, upper extremity throwing patterns were quite similar for each of the treatments. It can be concluded that the knee and ankle joints made significant adaptations to change in foot-strike style. The results indicate that the toe-strike technique, with addition of an extra decelerating lever, the foot, may improve the impact shock absorption qualities of the lower extremities. Above all this study illustrates the remarkable adaptation of a skilled performer who was able to accommodate modifications to his preferred pitching technique and maintain consistent pitching performance inspite of the treatments imposed. Further investigation is necessary in order to define any possible injury causing mechanisms due to foot placement in overarm baseball pitching.

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