A THREE-DIMENSIONAL KINEMATIC COMPARISON OF PITCHING TECHNIQUES BETWEEN MALE AND FEMALE FAST-PITCH SOFTBALL . PLAYERS

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The mechanics of the softball windmill pitch can provide insight into the critical features of different pitches to identify which parameters are different between pitches. In the softball windmill pitch, the pitcher's armrotates through approximately 360° in a near-vertical plane before reaching the release point. To achieve the greatest velocity, the ball should be released parallel to the hip and usually perpendicular to the ground with trunk and hip rotation occumng in the transverse plane. Ball velocities of three female subjects, measured by Adrian and Cooper (1989) for a slingshot style pitch, were between 19.5 and 24.6 m/s. It is proposed that the windmill pitch will produce higher velocities than the slingshot style based on greater range of motion achieved by the windmill technique. As found by Alexander and Haddow (1982) the upper arm segment reached its peak velocity .06 - .08 seconds before the forearm with the forearm and hand segments achieving their peak velocities almost simultaneously. The purpose of this study was to analyze the three-dimensional motion of selected mechanical parameters of various windmill softball pitches and to determine which of these parameters differ between the pitches.

METHODOLOGY

Five male and six female fast-pitch softball pitchers were filmed performing four different pitches during competition: fastball (FB), riseball (RB), change-up (CH) and curve (CR). Three-dimensional kinematic data were collected using two Panasonic AG-450 video camcorders positioned at approximately an 80" convergence angle to the pitching mound. The high speed shutters were set at 1/1000th speed and nominal frame rates of 30 Hz. The Direct Linear Transformation (DLT) algorithm was used for conversion of the two-dimensional data.

After filming the subjects, the Ariel Performance Analysis System, AST 386 computer, and Panasonic 7300 VCR set at 60 Hz were used in digitizing 17 data points. The views were captured. digitized, synchronized, and transformed. The data were smoothed with a digital filter smoothing package with cut off frequencies set between 5.0 and 10.0 Hz.

RESULTS AND DISCUSSION

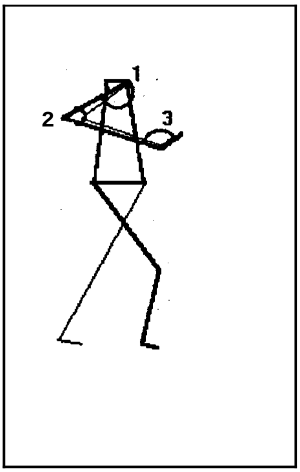
The results represent the averages of 6 female and 5 male subjects. Because of limited subject numbers, only trends in the data will be reported. Comparing linear velocities of the hand and ball between men and women demonstrated expected results (see Table 1). The peak velocities of the ball were greater for all pitches for the men because of their greater mass and ability to legally step off the pitching rubber. Greater mass and range of motion increase the velocity and linear momentum potential to the ball. For the men, the FB reached peak velocity .06 seconds after release (+), and the hand reached peak velocity .02 seconds before release (-). The women's FB reached peak velocity .03 seconds after release, and the hand reached peak velocity .05 seconds before release. The hand reaching peak velocity before release, permits an element of accuracy and transfers momentum to the ball.

Table 1.Linear Velocities

	Ball			Hand		
Men	Peak	Time*	Release	Peak	Time	Release
	(m/s)	**(sec)**	**(m/s)**	**(m/s)**	**(sec)**	**(m/s)**
FB	28.25	.06	20.76	17.76	**-.02**	16.20
RB	27.47	.04	19.15	17.98	**-.02**	14.01
CH	24.27	.05	17.45	16.64	**-.01**	14.12
CR	24.93	.03	21.78	15.24	**-.01**	13.92
Women						
FB	24.74	.03	22.63	16.49	**-.05**	16.49
RB	24.64	**.01**	24.30	17.21	**-.06**	12.38
CH	19.20	**-.02**	18.29	16.96	**-.06**	10.80
CR	23.41	.01	22.79	16.13	**-.05**	11.93

*When peak velocity is reached in relation to release point

Both the men and women pitchers displayed greatest velocities at maximum peak close to release for the FB. This could be because the FB permits the majority of the movement to occur as the wrist flexes to keep the ball moving in a linear path. Lower velocities were seen with the CH because the goal of the CH is to distract the batter by varying the ball's speed. However, the arm speed must remain the same as in the FB, but a decrease in wrist flexion (snap) has been identified as a contibuting factor for the decrease in velocity.



Stride lengths indicate different strategies are used for different pitches. The males exhibited strides of: 170.52 cm (FB); 174.97 cm (RB); 156.50 cm (CH); 163.66 cm (CR), and females: 156.35 cm (FB); **162.79 cm** (RB); 130.82 cm (CH); 137.28 cm (CR). Males displayed longer stride lengths because of their ability to legally step off the pitching rubber, prior to and after release, therefore increasing the time to build momentum during the pitching motion. The RB typically had the longest stride length of all the pitches because greater flexion of the rear knee is necessary in order to lower the release point. The lower release point is critical for producing backspin to the ball for proper lift. The FB may have a decrease in stride length compared to the RB because the stride is directly forward and more upright. The CH had the shortest stride length, as the forward momentum is decreased, to assist in the decreased final velocity of the ball at release.

The average resultant joint angles of the upper body were calculated to determine the angle at the shoulder, elbow, and wrist for the different pitches at release(**see** Table 2).

Table 2. Joint Angles at Release (Degrees)

MEN	Shoulder	Elbow	Wrist
FB	107.84.	156.76	144.32
RB	95.53	151.07	160.32
CH	97.08	154.53	163.59
CR	107.45	167.09	156.58
WOMEN			
FB	103.52	156.60	147.95
RB	100.72	144.85	146.89
CH	98.35	152.87	157.90
CR	100.39	148.46	160.86

For average resultant joint angles of the upper body, the angle at release for the FB was very similar for both men and women. The ball was released close to perpendicular (107" and 103°), the elbow slightly flexed (156") and the wrist flexed (144" and 147"). Both the men and women decreased wrist flexion and exhibited similar elbow angles for the CH. The CH should have very little wrist snap upon release to decrease the ball's velocity; yet, the elbow should closely follow the same angle as the FB to deceive the batter. However, variability could exist for the wrist action. The wrist action was more dificult to interpret because the data presented here was reflective of the resultant 3D angle. It was difficult to determine whether the action occurred at the wrist or radioulnar joint. For the CR, the men extended further at the elbow which was opposite for the women. The movement of the wrist, slightly different between the sexes, determined how the ball curves. Increased ball movement could be achieved by using both the wrist and the elbow together.

CONCLUSIONS

There have been several qualitative descriptions of the kinematics of the thrower's body during the softball windmill pitch (Adrian & Cooper, 1989). However, these descriptions have been based on two-dimensional quantitative data. Knowledge of the correct pitching mechanics, in three-dimensions, of the different types of windmill pitches would assist a pitcher in developing control of velocity, accuracy and flight pattems of each pitch. A pitcher must disguise what pitch is to be thrown to reduce the reaction time of the batter to adjust for the incoming pitch. From a practical aspect, the faster the ball is pitched, the earlier one must release it for it to arrive in the strike zone. The FB at release had the largest angle at the shoulder and elbow and smallest at the wrist. This would permit the pitcher to release the pitch earlier, create a longer lever, and allow maximum force to be imparted to the ball. The remaining pitches showed slight modifications at the shoulder, elbow and wrist in angular and linear components. Although this study dealt with only the joint angles and linear velocities of the upper body, each pitcher seems to vary their throwing style more in the forearm (elbow and wrist) than in the upper arm (shoulder) for the various pitches. As a coach. one would want their pitcher to be consistent in the 360" armswing and trunk/hip rotation, with minor modifications occumng at the wrist. Lower body mechanics may also vary between pitches, as was identified by different stride lengths.

REFERENCES

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Alexander, M.J. & Haddow, J.B. (1982). A kinematic analysis of an upper extremity ballistic skill: The windmill pitch. Canadian Journal of Applied Sport Science, 7, 209-217.