BIOMECHANICAL ANALYSIS OF THE FASTBALL THROWN FROM THE WIND-UP AND THE STRETCH

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INTRODUCTION

There is debate about how to best throw the fastball. A consumer publication cited a decrease in the use of the wind-up in favor of the stretch for a number of high profile Major League Baseball pitchers (Diamond, 2017).

Studies evaluating the role of ground reaction forces during pitching assessed its effect on upper body movements and pitching mechanics (Elliot et al., 1988; Guido & Werner, 2012; Kageyama et al., 2015) or compared the kinetic and kinematic differences based on age (Kageyama et al., 2015) or ability (Kageyama, et al., 2014). Other studies demonstrated differences in ball velocity between high and low velocity pitching groups (Kegeyama et al., 2014), or sought to differentiate between high and low velocity pitchers (Kageyama et al., 2015).

Some of this research assessed the relationship between pitching kinetics and the subsequent arm, wrist, or pitched ball velocity. Propulsive phase anterior force was correlated to wrist velocity (MacWilliams et al., 1998). On the other hand, ground reaction forces sometimes demonstrated no correlation with ball velocity (Oyama & Myers, 2017).

Most studies specifically examined the fastball (Guido & Werner, 2012; Kageyama et al., 2014; Kegeyama et al., 2015; Oyama & Myers, 2017) either for descriptive purposes, to compare subjects of different ability, or to assess pitching surfaces (Kageyama et al., 2014; Kageyama et al., 2015). The difference between the fastball from the windup versus the stretch has infrequently been studied. When it was, no kinetic differences between conditions were found (Dun et al., 2008; Elliot et al., 1998) and the kinetic analysis was limited to select aspects of the upper body (Dun, et al., 2008). Therefore, the purpose of this study was to assess kinetic and kinematic aspects of the propulsive and landing phase of pitching fastballs from the wind-up and stretch position. This study also assessed ball velocity in each condition.

METHODS

Subjects included 15 men (age = 19.47 ± 1.18 yr) who were former high school and college pitchers. Subjects were informed of the risks associated with the study and provided informed written consent. The study was approved by the institution's internal review board.

All subjects threw six fastballs from the wind-up as well as six fastballs from the stretch, into a net with a strike zone ten meters away. The pitch type was counterbalanced. The test pitches were performed on two force platforms (Accupower, Advanced Mechanical Technologies Incorporated, Watertown, MA, USA) deployed in series, and were countersunk and mounted flush to the floor. A pitching rubber was mounted to the first platform in the series. Data were acquired at 1000 Hz and analyzed in real time with proprietary software (Accupower, Advanced Mechanical Technologies Incorporated, Watertown, MA, USA). Pitch velocity was determined by Doppler radar (Speedster III, Bushnell Outdoor Products, Overland Park, KS). Data from the radar, as well as the force platform derived force-time record, algorithmic output, and center of pressure results were used in the post-processing.

Data were analyzed with a statistical software program (SPSS 26.0, International Business Machines Corporation, Armonk, New York). To evaluate the wind-up and stretch conditions, a paired samples *t*-test was used to compare differences in ball velocity, propulsive phase peak horizontal ground reaction force (GRF), peak vertical GRF, peak anterior horizontal to peak vertical GRF ratio (propulsive H:V), rate of vertical force production, and the rate of horizontal force production.

Landing phase variables included peak horizontal GRF, peak vertical GRF, peak anterior horizontal to peak vertical GRF ratio (landing H:V), rate of vertical force production, and rate of horizontal force production. Other variables in the analysis included the time, distance, and whole body velocity from propulsive phase to the landing phase. The trial-to-trial reliability of the dependent variables were assessed using average measures Intraclass correlation coefficients (ICC) and coefficients of variation (CV). The a priori alpha level was set at $p \leq 0.05$. Data are presented as mean ± SD.

RESULTS

Results of the analysis of the data for the fastball pitched in the wind-up and stretch conditions are shown in Table 1. The ICC's for the test exercises and all dependent variables ranged from 0.77 to 0.96 for the horizontal ground reaction force data, and 0.87 to 0.98 for the vertical ground reaction force data. Coefficients of variation for all data ranged from 13.9% to 28.5%. GRF = ground reaction force; Propulsive H:V = ratio of the horizontal anterior to vertical ground reaction force; RFD = rate of force development. Landing H:V = ratio of the horizontal posterior to vertical ground reaction force; V = Vertical; Propulsive H = horizontal anterior; Landing H = horizontal posterior.

Table 1. Data (mean ± SD) for the fastball from the wind-up and stretch (N = 15).

	Fastball - Wind-Up	Fastball - Stretch	Significance
Velocity ($m \cdot s^{-1}$)	33.17 ± 2.21	33.13 ± 2.40	p = 0.77
Propulsive V-GRF (N)	1124.48 ± 150.86	1115.84 ± 135.77	p = 0.69
Propulsive H-GRF (N)	419.32 ± 86.62	443.04 ± 78.72	p = 0.008
Propulsive H:V	0.37:1 ± .05:1	0.40:1 ± .05:1	p = 0.001
Propulsive V RFD ($N \cdot s^{-1}$)	13240.41 ± 1767.18	20382.69 ± 2467.79	p = 0.001
Propulsive H RFD ($N \cdot s^{-1}$)	4617.98 ± 1767.18	2794.78 ± 498.31	p = 0.001
Landing V-GRF (N)	1190.19 ± 184.05	1158.56 ± 159.71	p = 0.59
Landing H-GRF (N)	366.06 ± 108.14	363.92 ± 109.56	p = 0.70
Landing H:V	0.31:1 ± .07:1	0.35:1 ± .16:1	p = 0.32
Landing V-RFD ($N \cdot s^{-1}$)	14520.35 ± 2231.72	19270.73 ± 3509.31	p = 0.001
Landing H-RFD ($N \cdot s^{-1}$)	6925.94 ± 2043.40	7597.17 ± 2296.29	p = 0.001
Time (seconds)	0.41 ± 0.09	0.38 ± 0.10	p = 0.10
Distance (meters)	1.57 ± 0.10	1.55 ± 0.11	p = 0.30
Whole Body Velocity ($m \cdot s^{-1}$)	4.08 ± 0.86	4.28 ± 1.07	p = 0.17

GRF = Ground Reaction Force, RFD = Rate of Force Development, V = Vertical, H = Horizontal, H:V = Ratio of Horizontal to Vertical GRF.

DISCUSSION/CONCLUSION

This is the first study to demonstrate significant differences between pitching from the wind-up and the stretch. Only two other studies assessed these two pitches. One study showed that the GRF were similar between these pitches (Elliot et al., 1988). The other used only motion analysis and found no temporal, kinematic, or kinetic differences between the fastball types (Dun et al., 2008). The current study may have found differences when others did not, due to dissimilar methodology including the used of ground based kinetics accrued via force platforms, instead of inverse dynamics and a focus on upper body kinetics (Dun et al., 2008).

In the current study, the stretch condition produced more horizontal GRF, a higher propulsive H:V, and a greater vertical rate of force development in the propulsive phase, and a higher vertical rate of force development upon landing. Previous research demonstrated no significant differences in either the vertical or horizontal forces between these pitches (Elliot et al., 1988). It has been suggested that pitching from the stretch may produce less kinetic energy from the legs with less whole body displacement (Dun et al., 2008). Results from the present study found no difference in vertical GRF, no difference in distance, but greater horizontal GRF, from the stretch.

Pitching from the stretch was thought to be quicker than from the wind-up (Diamond, 2017; Dun et al., 2008). In the current study, the mean time was lower and whole body velocity higher from the stretch. In the current study, the propulsive H:V in the stretch condition was similar to the ratio derived from other research (Oyama & Myers, 2017) and the propulsive phase vertical and horizontal forces for both pitches were similar to those previously demonstrated (Elliot et al., 1988; Oyama & Myers, 2017).

The pitching velocity in the current study averaged about 33 m·sec-1, while others threw 34.87 m·sec-1 (Guido & Werner 2012) to 38.5 m·sec-1 (Dun et al., 2008). In the current study, the kinetic differences between pitches yielded a non-significant 0.04 m·sec-1 difference in ball velocity.

Pitching from the wind-up and stretch is accomplished using different biomechanical strategies. Training to improve pitching from the wind-up should feature exercises that accentuate the development high horizontal rates of force production in the propulsive phase. Training to improve pitching from the stretch should focus on improving horizontal GRF and a higher H:V in the propulsive phase, and the ability to manage the horizontal and vertical rate of forces production upon landing.

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