

## **THE CHARACTERISTICS OF STRIDE LEG GROUND REACTION FORCE BETWEEN DIFFERENT STRIDE TYPES BASEBALL PITCHERS WHILE PITCHING**

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The purpose of current study was to compare the ground reaction forces (GRF) of the stride leg in baseball pitchers using two different pitching stride techniques. Fourteen college pitchers volunteered as participants and made maximum effort pitches on an indoor mound toward a 8 m away target. The ball velocity were measured by a radar gun, the GRF were measured by a forceplate, and the trajectory of pelvis center were measured by a motion analysis system to classify pitcher's strides as tall-and-fall (TF) or dip-and-drive (DD). There were no significant difference between two groups in ball velocity and stride leg GRF during pitching, and the ball velocity were significantly correlated with the vertical GRF of stride leg at ball release in TF group. It suggested that the different pitching technique might be used for different stride types.

**KEY WORDS: stride leg, tall-and fall, dip-and-drive, stride type of pitching**

**INTRODUCTION: Lower extremity plays an important role in baseball pitching though the ground reaction force (GRF). There were two different lower extremity stride types in baseball pitching: tall-and-fall (TF, Figure 1a) and dip-and-drive (DD, Figure 1b). The TF type pitchers kept their body as tall as possible, and threw the ball at the highest position during the movement; the DD type pitchers dip down a lot to drive or push off the rubber to gain momentum (Ryan & House, 1991); the DD type pitching depended on the press force of pivot leg more than the TF type pitching (Chen, Tang, Kung, & Hung, 2010). The stride movement of lower extremity while pitching influenced the movement of pelvis, torso, and upper extremity to influence the pitching performance and injury risks (Oliver & Keeley, 2010). Although the GRF during pitching were studied (Chen et al., 2010; Elliott, Grove, & Gibson, 1988; MacWilliams, Choi, Perezous, Chao, & McFarland, 1998; McNally, Borstad, Oñate, & Chaudhari, 2015), the difference of stride leg GRF between TF and DD stride types were still unclear. This study aimed to investigate the difference of stride leg GRF between TF and DD stride**

types and the correlation between ball velocities and stride leg GRF, in order to understand the stride skills as the reference of training.

**METHODS:** Fourteen college male baseball pitchers volunteered as participants. All participants provided written informed consent to participate in the study after being informed of its purpose and associated risks, and this study was approved by the Institutional Review Board of National Taiwan Sports University. After warm up with personal routine, the participants were asked to pitch 3 called-strikes trail with the best effect, and the data of fastest strike trail were used to analysis. Limited to experience space, the distance between pitching rubber and strike zone were 8 meters. A Stalker Sport speed gun was used to measure ball release velocity, and an 8-cameras (200Hz) Eagle System were used to measure marker trajectory variables. A AMTI forceplate that set as an indoor mound were used to collect the GRF data and verify the instant of stride foot contact the ground with 1000 Hz sampling rate. The marker position data were filtered using a fourth order Butterworth low-pass filter with a cut-off frequency of 13.4 Hz (Escamilla, Fleisig, Barrentine, Zheng, & Andrews, 1998) by the Matlab software. The GRF data from stride leg contact the ground to ball release were used to analyze. Based on the definition of TF and DD stride types (Ryan & House, 1991), the normalized trajectory of pelvis center during stride phase was calculated to define the participants into different groups: if the trajectory of pelvis center move forward first, the participant was a TF pitcher (Figure 2a); if the trajectory of pelvis center move downward first, the participant was a DD pitcher (Figure 2b). Five participants were grouping as TF group, and nine participants were grouping as DD group. The statistical analysis between TF and DD groups were performed with the SPSS software. The T-test ( $p < 0.05$ ) were performed for each variables to identify differences between two stride types, and the Pearson Correlation ( $p < 0.05$ ) were performed for the ball velocity and the GRF of stride leg.

**RESULTS and DISCUSSION:** The comparison of parameters between TF and DD groups was showed in Table 1. There were no significant difference between the TF group (age:  $20.9 \pm 1.8$  years, body height:  $1.8 \pm 0.1$  m, body weight:  $79.3 \pm 9.7$  kg) and the DD group (age:  $21.0 \pm 1.2$  years, body height:  $1.8 \pm 0.1$  m, body weight:  $86.6 \pm 11.8$  kg) in ball velocity and stride leg GRF during pitching. Chen et al. (2010) showed that the TF group were significantly lower in the GRF impulse in pivot leg, and reached the time of minimum knee flexion angle & peak anterior-posterior and vertical pivot leg GRF significantly later than the DD group. It suggested that although the skill of pivot leg difference between TF and DD pitchers were different, and the role of stride leg were similar to transfer energy up to the pelvis and trunk as a stabilizing leg (Matsuo, Escamilla, Fleisig, Barrentine, & Andrews, 2001).

The correlation of the ball velocity and the GRF of stride leg in TF and DD groups were showed in Table 2. The ball velocity were significantly correlated with the vertical GRF of stride leg at ball release in TF group. McNally et al. (2015) showed that the stride leg GRF were strong related with the ball velocity. In current study, only the stride leg GRF of the TF group showed the correlation with the ball velocity. It suggested that the different pitching technique might be used for different stride types.

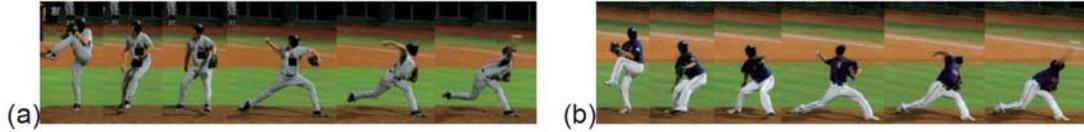
**CONCLUSION:** The role of stride leg were similar between TF and DD pitchers. Only the stride leg GRF of the TF group correlated with the ball velocity, it suggested that the different pitching technique might be used for different stride types. Future study for different stride types should be needed to understand and grasp the different pitching skill of different stride types.

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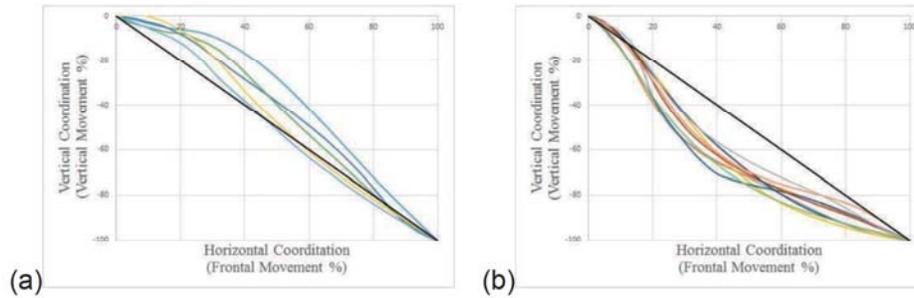
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**Acknowledgement**

Thanks for the support of NSC grant 99-2410-H-179 -004 -MY2.



**Figure 1: The pitching motion of a typical TF (a) and DD (b) stride type pitchers.**



**Figure 2: The trajectory of pelvis center. (a): TF Groups; (b): DD Groups.**

**Table 1**

**Comparison of ball velocity and stride leg GRF parameters between TF and DD groups**

	TF Group (N=5)	DD Group (N=9)	p value
Ball Velocity (m/s)	34.66±1.76	33.44±3.15	0.459
X (%BW)	77.09±13.43	84.35±9.35	0.255
Xt (%T)	83.05±5.31	70.18±22.86	0.246
Stride Leg			
Z (%BW)	186.28±36.82	186.46±28.90	0.992
Zt (%T)	86.24±7.04	84.08±8.18	0.629
Xrel (%BW)	65.31±15.54	58.26±19.49	0.502
Zrel (%BW)	161.12±28.75	154.65±32.16	0.715

\*: p<0.05

X: peak anterior-posterior GRF; Xt: the time of peak anterior-posterior GRF; Z: peak vertical GRF; Zt: the time of peak vertical GRF; Xrel: anterior-posterior GRF at ball release; Zrel: vertical GRF at ball release; %BW: percentage of body weight; %T: percentage of time from stride foot contact to ball release.

**Table 2**

**Correlation of the ball velocity and GRF of stride leg**

		TF Group (N=5)					DD Group (N=9)						
GRF of stride leg		X	Xt	Z	Zt	Xrel	Zrel	X	Xt	Z	Zt	Xrel	Zrel
Ball	r value	0.634	-0.143	0.773	0.076	0.746	0.942*	-0.068	0.284	0.264	0.599	0.303	0.436
Velocity	p value	0.250	0.818	0.125	0.904	0.148	0.017	0.863	0.458	0.493	0.088	0.428	0.241

\*: p<0.05