CHARACTERISTICS OF A WELL-DONE BREAKING PITCH IN BASEBALL

Hirotaka Nakashima[1] and Shinji Sakurai[2]

Graduate School of Health and Sport Sciences, Chukyo University, Toyota, Japan[1]
School of Health and Sport Sciences, Chukyo University, Toyota, Japan[2]

This study aimed to quantify well-done breaking pitches as evaluated by experienced catchers in baseball. Twenty college baseball pitchers threw one pitch for each type of pitch that they typically played in a game. Pitched ball velocity, spin rate, spin component, and displacement were calculated. Nine catchers of the same team evaluated each breaking pitch (curveball, slider, and changeup) of all the pitchers, and the relationships between the catchers' evaluation and the quantitative variables were then investigated. Thus, with respect to the curveball, significant correlations were observed between the catchers' evaluation and total spin rate, back spin, and vertical displacement. With respect to the slider, significant correlation was observed between the catchers' evaluation and ratio of the velocity of the slider relative to the fastball. With respect to the changeup, significant correlation was not observed for any of the variables. The results are expected to act as a good benchmark for pitchers to improve their breaking pitches.

KEYWORDS: breaking ball, curveball, slider, changeup.

INTRODUCTION: Recently, various measurement systems, such as ball tracking system, were introduced in the Major League Baseball. In particular, the spin of the pitched ball has attracted considerable attention.
Extant studies investigated the pitched ball spin. Nagami et al. (2011) reported on the spin characteristics of fastballs, and Jinji et al. (2011) indicated the manner in which the fastball spin was affected by the kinematics of the pitcher. In addition, Higuchi et al. (2013) reported the effect of the spin of the fastball on batting performance. Hence, several studies focused on the fastball. However, with respect to breaking pitches, although previous studies revealed spin characteristics and their trajectories, well-done breaking pitches have not yet been identified (Jinji and Sakurai, 2006; Whiteside et al., 2016). In coaching situations, coaches or catchers determined whether the breaking pitches thrown by pitchers were good or bad and advised them on how to improve their performance. If the characteristics of well-done breaking pitches were revealed, then communication can occur more smoothly. In addition, pitchers can practice a breaking pitch with a well-marked goal. This leads to efficient training and improvements in their performance.
This study aimed to quantify well-done breaking pitches as evaluated by experienced catchers in baseball.

METHODS: Twenty college baseball pitchers from a team participated in the study (age: 19.6$\pm$0.9 years, body height: 1.78$\pm$0.04 m, body weight: 76.5$\pm$7.4 kg) in which the pitching motion was over-hand or three-quarter throw. Six pitchers were left-handed and the other pitchers were right-handed. Each pitcher threw one pitch for each type of pitch they typically played in a game. Every pitcher threw more than two types of pitches including fastball. This study focused only on the curveball, slider, and changeup, which were thrown by more than ten pitchers.
To record the pitched ball velocity, a speed gun (Sports Rader Gun HP-2, Toa Sports Machine) was used. The pitched ball velocity of two pitchers were recorded using high-speed video cameras (MEMRECOM MX, Nac Image Technology) as a substitute for the speed gun, which could not be used. The frame rate and exposure time was set at 500 fps and 1/5000 s, respectively. The velocity immediately after ball release was recorded. A high-speed video camera (Fastec TS3, Nihon Fastec Imaging) was placed at the back of the pitchers (Figure 1(a)) to record the pitched ball spin. The frame rate and exposure time were set at 1000 fps and 1/10000 s, respectively. The video image (Figure 1(b)) was used to calculate the spin rates and spin components (back spin, spiral spin, and side spin) of the pitched balls by digitising

the marks on the ball via the method described by Jinji and Sakurai (2006). The ball displacements (vertical and horizontal) from the ball release to the home plate were estimated from the pitched ball velocity and spin components via the method described by Nagami et al. (2016). In addition, the ratios of the velocity and displacement of the breaking pitches relative to the fastball were also calculated. Lateral inversion processing was performed on the data of the left-handed pitchers to integrate the data of the left- and right-hand pitchers.
Nine catchers who belonged to the same team as the pitchers (age: 19.4±0.9 years, catcher experience: 7.6±3.4 years) evaluated the breaking pitches of each pitcher. The evaluation system corresponded to a five-point grade system (1: very poor, 2: poor, 3: fair, 4: good, 5: very good). Pearson's product-moment correlation coefficients were calculated to investigate the relationship between the mean value of the evaluation from nine catchers and quantitative variables. The significance level was set at $p < 0.05$.

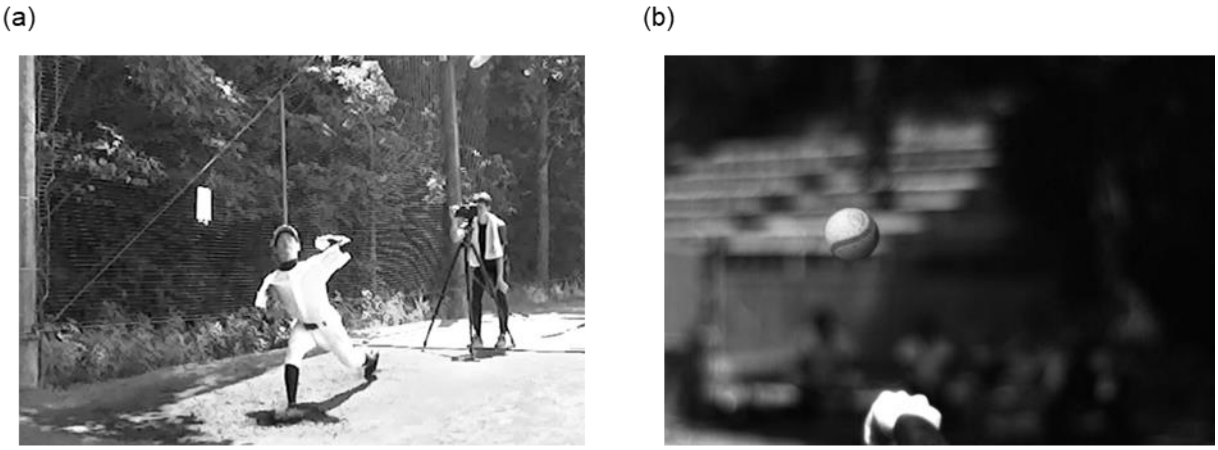

Figure 1: (a) Condition of the experiment, (b) video image recorded by the camera.

RESULTS: Sixty-one pitches (20 fastballs, 18 curveballs, 11 sliders, and 12 changeups) were analysed in total. Table 1 summarizes the means, maximums, and minimums of the velocities and spin rates of the fastballs, curveballs, sliders, and changeups. Figure 2 shows the vertical and horizontal ball displacement from the ball release to home plate. With respect to the curveball, significant correlations are observed between the evaluation by the catchers and spin rate (r = 0.704, Figure 3(a)), back spin rate (r = -0.694, Figure 3(b)), and vertical displacement (r = -0.702, Figure 3(c)). With respect to the slider, significant correlation is observed between evaluation by catchers and the ratio of the velocity of the slider relative to the fastball (r = 0.684, Figure 3(d)). With respect to the changeup, significant correlation is not observed between any variables and the catchers' evaluation.

Table 1: Mean and range of the velocity and spin rate of all pitches.

	Velocity [km/h]			Spin Rate [rpm]		
	Mean±SD	Max.	Min.	Mean±SD	Max.	Min.
Fastball	133.5±4.7	142.0	125.0	2093±174	2412	1746
Curveball	103.9±6.2	116.0	91.0	1965±332	2702	1262
Slider	117.1±6.0	123.0	108.0	2101±325	2411	1293
Changeup	114.8±4.7	121.0	108.0	1225±209	1602	840

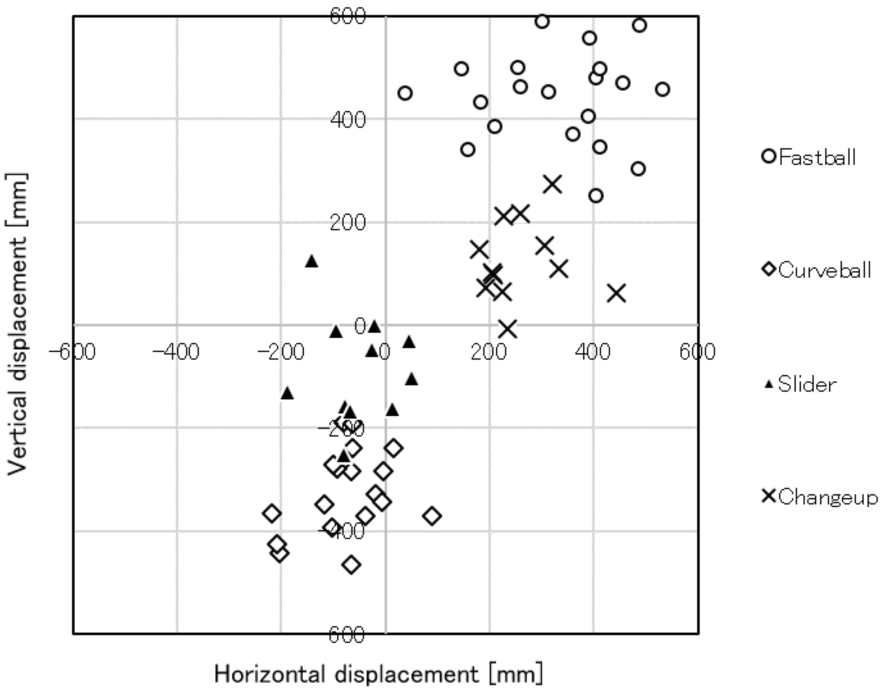

Figure 2: Ball displacement from the ball release to home plate.

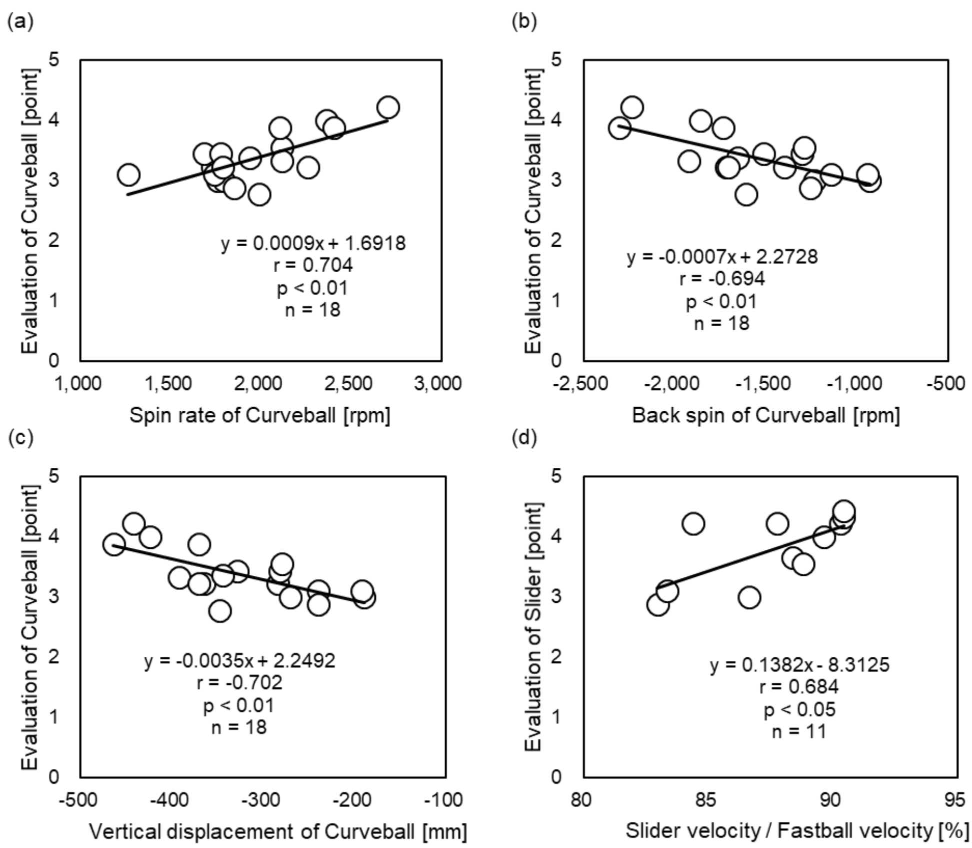

Figure 3: Relationship between catchers' evaluation of the breaking pitches and calculated variables.

DISCUSSION: As reported by Whiteside et al. (2016), the fastball of each pitcher was the fastest of their pitch types.

With respect to a curveball, a significant positive correlation was observed between the evaluation and spin rate. Furthermore, significant negative correlations were observed between the evaluation and the amount of back spin and vertical displacement. Hence, the balls that had greater top spin and were often dropped were highly evaluated. Conversely, significant correlation was not observed between the evaluation and amount of side spin or horizontal displacement. The curveball corresponded to the slowest of the three breaking pitches investigated in the study. In most cases during a game, pitcher throws a curveball to upset the batter's timing and obtain a strike when the batter waits for the fastball. Therefore, it was considered as difficult for batters to swing and hit balls in which the trajectory of the ball rises significantly and then sharply drops because batters are forced to change the direction of their eyes and thereby upset their timing.

With respect to the slider, significant positive correlation was observed between the evaluation and ratio of the velocity of the slider relative to the fastball. Significant correlation was absent in any other variables. Although the spin rate of the slider exceeded those of the other types of pitch, the ball displacements were relatively small because the spin axis was directed to the pitched direction. A pitcher throws a slider mainly to force batters to swing and miss. If the balls were slow and largely curved or dropped like a curveball, then batters would not swing. Therefore, it was considered that the balls in which the velocity gap between fastball and slider was small (i.e., it is difficult to distinguish a fastball) were highly rated.

With respect to the changeup, significant correlation was not observed between any variables and the catchers' evaluation. The data range of both velocity and spin rate of changeups measured in the study was narrow when compared with other types of pitch. This is one of the reasons as to why significant correlation was not observed.

It was possible to quantify well-done breaking pitches evaluated by the catchers. Recently, even amateur players can easily measure their ball velocity or spin rate. The result of the study is a good benchmark to evaluate pitcher's skills and improve their performance.

The study includes a limitation. In the study, we focus on the college baseball pitchers. However, the result differs if there are differences in their ability levels. Thus, in a future study, it is necessary to expand the range of the players from high school players to professional players.

CONCLUSION: The study quantified well-done breaking pitches in baseball. With respect to the curveball, it was considered difficult for batters to swing and hit the balls wherein the trajectory changes sharply with vertical displacement from the expected point. With respect to the slider, the balls in which the velocity gap between fastball and slider was small (i.e., difficult to distinguish a fastball) were highly rated.

REFERENCES

Higuchi, T., Morohoshi, J., Nagami, T., Nakata, H., & Kanosue, K. (2013). The effect of fastball backspin rate on baseball hitting accuracy. *Journal of Applied Biomechanics*, 29, 279-284.

Jinji, T., Sakurai, S., & Hirano, Y. (2011). Factors determining the spin axis of a pitched fastball in baseball. *Journal of Sports Sciences*, 29, 761-767.

Jinji, T. & Sakurai, S. (2006). Direction of spin axis and spin rate of the pitched baseball. *Sports Biomechanics*, 5, 197-214.

Nagami, T., Morohoshi, J., Higuchi, T., Nakata, H., Naito, S., & Kanosue, K. (2011). Spin on fastballs thrown by elite baseball pitchers. *Medicine & Science in Sports & Exercise*, 43, 2321-2327.

Nagami, T., Higuchi, T., Nakata, H., Yanai, T., & Kanosue, K. (2016). Relation between lift force and ball spin for different baseball pitches. *Journal of Applied Biomecanics*, 32, 196-204.

Whiteside, D., McGinnis, R. S., Deneweth, J. M., Zernicke, R. F., & Goulet, G. C. (2016). Ball flight kinematics, release variability and in-season performance in elite baseball pitching. *Scandinavian Journal of Medicine & Science in Sports*. 26, 256-265.

ACKNOWLEDGEMENTS: The study was supported by a grant from Yamaha Motor Foundation for Sports.