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Differences in Baseball Batting Movement Strategies between Facing a Pitcher and Pitching Machine

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SUMMARY

It is generally accepted that pitching machines cannot completely simulate a real pitcher's pitching motion and ball trajectory. To understand if a batter would change batting movement strategies due to visual information provided by a pitching machine as opposed to a real pitcher, three professional baseball players in the minor league in Taiwan were recruited for examining several event instants and vertical ground reaction forces of their batting movements. It was found that every subject started taking a forward step earlier with higher variability, and shifted body weight more slowly in facing a pitching machine. The results may be attributed to lack of visual clues which could be found in a real pitcher's whole body kinematics, causing uncertainty for the batter. Therefore, it was concluded that athletes would change batting movement strategies in the batting practice with a pitching machine. It needs to be noted that it is premature to generalize this conclusion to larger population due to small sample size used in this study.

INTRODUCTION

Although pitching machines have become useful equipment for baseball batting training, they still cannot completely simulate a real pitcher's pitching motion, and may result in batters changing their batting movement strategies. The purpose of the present study was to verify this hypothesis by analyzing batters' movement timings and vertical ground reaction forces (GRF).

METHODS

Three professional baseball players in the minor league in Taiwan were recruited (age 29.33±1.89 years; height 1.74±0.03 m; weight 79.68±0.33 kgw) in this study. The experiment was conducted in an indoor batting cage where the players practice regularly. The pitching machine used was an arm action machine (Toa Sports Machine Inc.) which delivered pitches 13m away from the home plate.

Two force plates (Advanced Mechanical Technology, Inc.) were used to acquire GRF values and synchronized with high speed cameras. A 200Hz high speed camera (Balser AG) recorded the timings of bat-ball impact. Another 650Hz camera (Mega Speed Corp.) recorded the instant of ball release. Stepping and landing were acquired from GRF data.

The experiment consisted asking the participants to hit the ball pitched by a pitcher (PR) and a pitching machine (PM) in the first and second sessions, respectively. Only pitches with speed from 58 to 60 mph (measured by a radar gun) and inside of the strike zone were analyzed. Pitches that were fouls or missed by batters were still analyzed while noted as "unsuccessful but valid" trials. Raw GRF data were filtered by a fourth-order, zero-phase, low pass Butterworth filter and normalized by body weight (BW). The temporal features and kinetic parameters used in this study were adapted from Katsumata's work [1]. Data were compared in PR and PM conditions with the significance level $p = .01$.

RESULTS AND DISCUSSION

For the ease of illustration, results from only one subject (S2) were chosen for discussion (Table 1). The timings of taking a step forward in S2 had significant differences between facing a PR and a PM (320.5±61.8ms and 556.5±175.5ms prior to ball impact, respectively; p_v=.089 is the p value of Levene test). This shows that S2 initiated stepping movement earlier when facing a pitching machine.

Timings of landing the forward step were also significantly different under PR and PM conditions (227.5±11.4ms and 182.5±52.0ms after ball impact, respectively; p_v<.05) with a significantly longer stride phase in the latter condition. The results revealed altered timings in movement strategies when facing the pitching machine. Ranganathan and Carlton concluded similarly [2] by indicating that both the start of the step and step duration were coupled to the pitcher's kinematics. Therefore, without actual pitching motions as a feedback mechanism to the batter, it was hard to estimate timings of the upcoming balls from the pitching machine, and consequently resulting in increased variability and altered temporal features.

A study about anticipation of soccer goalkeepers proposed that expert goalkeepers try to extract information for as long as possible and hence initiate their actions relatively late [3]. This observation was adopted to explain the anticipation strategy under different levels of uncertainty (possibility of the direction of the throw) for handball goalkeepers [4]. It was found that with increased uncertainty, goalkeepers tended to delay the start of their movement and reduced the velocity of their center of mass before ball release. It was argued that when the uncertainty increased, a goalkeeper was unable to perceive sufficiently clear clues and slowing down enabled modification of movement direction once a mistake was made. This phenomenon seems to conflict with our results in that the batter started to step earlier. However, it actually provides a good explanation: because the pitching machine only provided limited clues, the batter chose to step earlier to avoid missing the appropriate initiation timing, and simultaneously prolonged his stride duration to continue perceiving information. The batter did not delay stepping or swinging as in soccer researches [3][4] probably due to distinct feathers of the two kinds of sports and to the following reasons. Firstly, goalkeepers need to avoid giving information to the thrower (or kicker) but batters need not; secondly, it is difficult for goalkeepers to correct movement in a wrong direction, while batters concern about timing but not spatial uncertainty. Moreover, batters still have chances to correct timing of weight shifting after landing the front step. Taking more risks to obtain more clues is unnecessary.

Vertical ground reaction forces (GRF_z, Fig. 1) remained high until landing the front foot, suggesting that body weight was supported by the rear foot during the stride phase. Okihiro indicated the importance of ball hitting preparation by shifting body weight to maintain bat swing power [5]. It was also suggested that shifting body weight too early may reduce swing power, and batters should keep body weight on the rear foot when taking a stride [6]. These suggestions about batter's stride strageties correspond well with the present results.

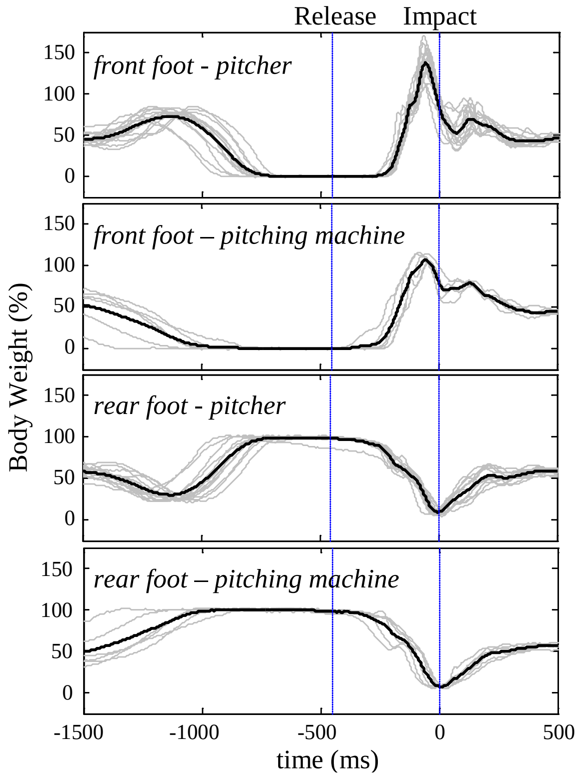

Figure 1: GRF_z in PR & PM conditions on each foot were aligned at the moment of ball-bat impact. Gray and black lines repersent individual and averaged data, respectively.

Peak GRF_z on the front foot was significantly smaller in PM condition (with 145.7±18.4% BW and 112.2±13.6% BW in PR and PM conditions, respectively), but valley GRF_z on the rear foot was less than 10% BW and had no significant difference between the two conditions. This suggests that S2 shifted his weight onto the front foot at landing in both conditions. Smaller peak GRF_z on the front foot indicated reduced impact force at landing in PM condition, and could be confirmed by decreased average loading rate in PM (with 0.86±0.17 % BW/ms and PM 0.55±0.13 % BW/ms in PR and PM conditions, respectively). The athlete probably slowed down weight shifting by decreasing the horizontal propulsion force and stride distance for better control of weight distribution under the condition with less visual cues.

Table 1: Mean & SD of temporal features and kinetic parameters. Timing of ball impact was set at 0.

temporal feature unit: ms	Mean		SD	
	P	PM	P	PM
Release before Impact	-453.8	-447.1	10.1	16.6
Stepping before Release	-320.5**	-556.5	61.8	175.5
Landing after Release	227.5**	182.5	11.4*	52.0
Swing before Impact	-228.9*	-236.5	8.2	9.0
Peak GRF_z before Impact	-59.1	-50.1	11.6	18.3
Valley GRF_z relative to Impact	2.0	13.0	18.3	28.4
Peak GRF_z value (BW%)	145.7**	112.2	18.4	13.6
Valley GRF_z value (BW%)	7.6	7.5	1.9	3.7
Average Loading Rate (BW%/ms)	0.86**	0.55	0.17	0.13
pitching speed (m/s)	26.5	26.6	0.29	0.34

Note: **p*<.05, ***p*<.01.

CONCLUSIONS

When facing a pitching machine, the subject stepped earlier with longer stride duration and slower weight transition. Variability in most temporal features showed an increasing tendency from PR to PM conditions yet lacking significant difference. The batter did change batting movement strategies in facing a pitching machine. It is suggested that pitching machines can only be an assistant device but cannot replace real pitchers for serious batting practice.

REFERENCES

1. Katsumata, H., *A functional modulation for timing a movement: A coordinative structure in baseball hitting*, Human Movement Science, **26**(1), 27-47, 2007
2. Ranganathan, R., & Carlton, L. G., *Perception - Action coupling and anticipatory performance in baseball batting*, Journal of Motor Behavior, **39**(5), 369-380, 2007
3. Savelsbergh, G. J. P., Van der Kamp, J., Williams, A. M., & Ward, P., *Anticipation and visual search behaviour in expert soccer goalkeepers*, Ergonomics, **48**(11-14), 1686-1697, 2005
4. Gutierrez-Davila, M., Rojas, F. J., Ortega, M., Campos, J., & Parraga, J., *Anticipatory strategies of team-handball goalkeepers*, Journal of Sports Sciences, **29**(12), 1321-1328, 2011
5. Okihiro, Michael M., *Coach Manju Nitta's Baseball Secrets*, Bloomington, IN: Authorhouse, 2011
6. Scarlett, W. George, Chertok, G., Lipton, J.L., Gittleman, S., & Johanson, E.S., *The Baseball Starter: A Handbook for Coaching Children and Teens*, Jefferson, NC: McFarland & Company, 2009