Hitting Kinematics for Precise Ball-Bat Contact in Collegiate Baseball Hitters

Jun Misaki[1], Takatoshi Higuchi[2], Ryo Tsuchikane[1], Hiromichi Saeki[3] and Tadao Isaka[3]
[1]*Graduate School of Sport and Health Science, Ritsumeikan University, 1-1-1, Nojihigashi, Kusatsu, Shiga, 525-8577, Japan*
[2]*Faculty of Socio-Environmental Studies, Fukuoka Institute of Technology, 3-30-1, Wajiro-higashi, Higashiku, Fukuoka, 811-0295, Japan*
[3]*College of Sport and Health Science, Ritsumeikan University, 1-1-1, Nojihigashi, Kusatsu, Shiga, 525-8577, Japan*

Keywords: Baseball, Hitter, Precision, Ball-Bat Contact.

Abstract: In baseball, higher bat velocity and the bat control are required for the successful hitting. Although kinematical factors related bat velocity have been studied, the knowledge about hitting kinematics related ball-bat contact precision is limited. The aim of this study was to examine the hitting kinematics for precise ball-bat contact in collegiate baseball hitters. Ten collegiate baseball field players completed 20 swings at a ball on the baseball tee, and their joint angles were calculated. The results indicate that hitters with lower precision in ball-bat contact might have excessive variability in joint angles in trail arm.

1 OBJECTIVES

Hitting a baseball has been described as one of the most difficult tasks in sports. Baseball hitters should accelerate the bat head within short duration, and lead the bat toward the appropriate location. Therefore, higher bat velocity and the bat control are required for the successful hitting (Morishita et al, 2013).

A previous study showed that collegiate and professional baseball players hit a ball on the baseball tee with highly precise ball-bat contact. (Higuchi et al, 2013). Although kinematic factors related bat velocity have been studied (Welch et al, 1995; Escamilla et al, 2009; Inkster et al, 2010), the knowledge about hitting kinematics related ball-bat contact precision is still limited. For the coaching on hitting precision based upon the scientific evidences, the investigation about hitting kinematics related precise ball-bat contact should be required.

This study aims to examine the hitting kinematics for precise ball-bat contact in collegiate baseball hitters.

2 METHODS

2.1 Participants

Ten male collegiate baseball field players (Age: 19.0 ±0.0 years, Height: 1.778±0.051 m, Body mass: 75.3±7.3 kg) were participated in this study. The mean length of their baseball experience was 11.1 ± 2.2 years. Before the experiment, informed consent was obtained from all participants for their participation in this research. The Ethics Committee on Human Research of Ritsumeikan University approved this study.

2.2 Experimental Procedures

The experiment was conducted in the indoor laboratory. A target board was set in front of the participants (Figure 1). The subjects were instructed to hit a ball on the baseball tee toward the center point of the target board. After sufficient warm-up and practice hitting, the participants performed two sets of 10 trials. The heights of baseball tee were determined as the heights of anterior superior iliac spine in each subject.

Misaki, J., Higuchi, T., Tsuchikane, R., Saeki, H. and Isaka, T.
Hitting Kinematics for Precise Ball-Bat Contact in Collegiate Baseball Hitters.
In *Extended Abstracts (icSPORTS 2016)*, pages 31-34

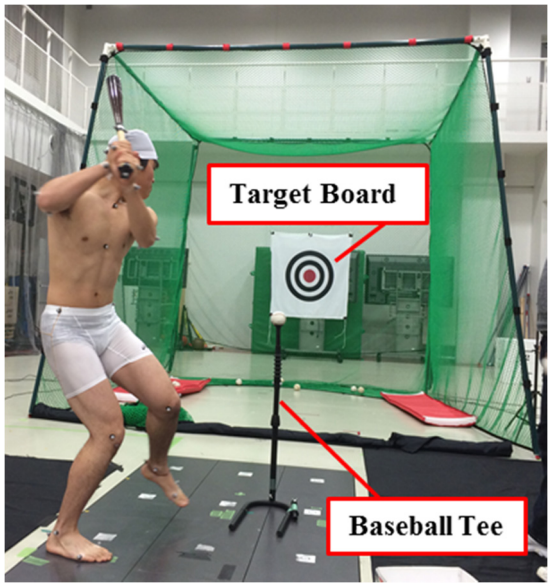

Figure 1: Experimental setting.

2.3 Data Collection

Movements of the bat and ball were recorded using two synchronized, high-speed video cameras (MEMRECAM fx-K5, Nac Image Technology, Japan) with 1000 frames/sec. Forty-two reflex markers were attached to the body landmark of participants and baseball bat. Those markers were captured by motion capture system (MAC 3D, Motion Analysis Corporation, USA) at 500Hz.

2.4 Data Processing

The image data of bat head, bat grip, and ball center were manually digitized using motion analysis software (Frame Dias V, DKH, Japan). The three-dimensional coordinates were obtained with the direct linear transformation method. The image at the instant of ball-bat contact was used for the analysis. We defined the area formed by standard deviation in short and long axes on the bat coordinate as an index of precision at ball-bat contact (Figure 2).

To smooth the motion capture data, marker coordinates were filtered using a lowpass Butterworth digital filter with a cutoff frequency of 13.3 Hz (Welch et al, 1995; Inkster et al, 2010). We used a rigid link model that contains two trunk segments and 12 upper/lower joints. Therefore, 30 angles were calculated as kinematic variables of the body. Segments/joints (angles) were, thorax and pelvis (anterior/posterior tilt, right/left tilt, right/left rotation), shoulder (flexion/extension, abduction/adduction, internal/external rotation), elbow (flexion/extension, pronation/supination), wrist (palmar/dorsi flexion, radial/ulnar deviation), hip (flexion/extension, abduction/adduction, internal/external rotation), knee (flexion/extension), ankle (dorsi/plantar flexion), respectively. Following the joint angle calculation, coefficient of variation (CV) in each angle was worked out as a kinematical variable. All processing of motion capture data were performed using Visual 3D (C-Motion, Inc., USA).

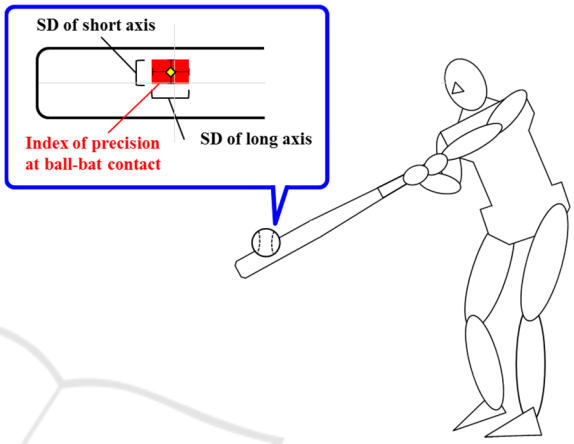

Figure 2: Index of precision at ball-bat contact.

2.5 Visualization of Results

We visualized the CV value of each angle in a forward swing phase. The forward swing phase is defined as the phase between swing initiation and ball-bat contact. The data were then time-normalized to 100% using a cubic spline (Kawamura et al, 2008). Visualization process was conducted using Matlab 2014a (Mathworks, Inc., USA).

3 RESULTS

Figure 3 shows the results of the visualization of CV (%) in forward swing phase of all participants (P1 to P10). In figure 3, the degrees of CV were shown as heat maps. Red zones indicate higher value, blue ones represent lower value. Graphs of P1 to P10 were in order based on the index of precision at ball-bat contact; P1 was the most precise hitter; P10 has the lowest precision in all participants.

In particular, higher or medium values of CV were observed in the trail shoulder, elbow, and wrist of P5 to P9. Additionally, CV in thorax and pelvis rotation showed medium or higher value in early to intermediate phase of swing across all participants.

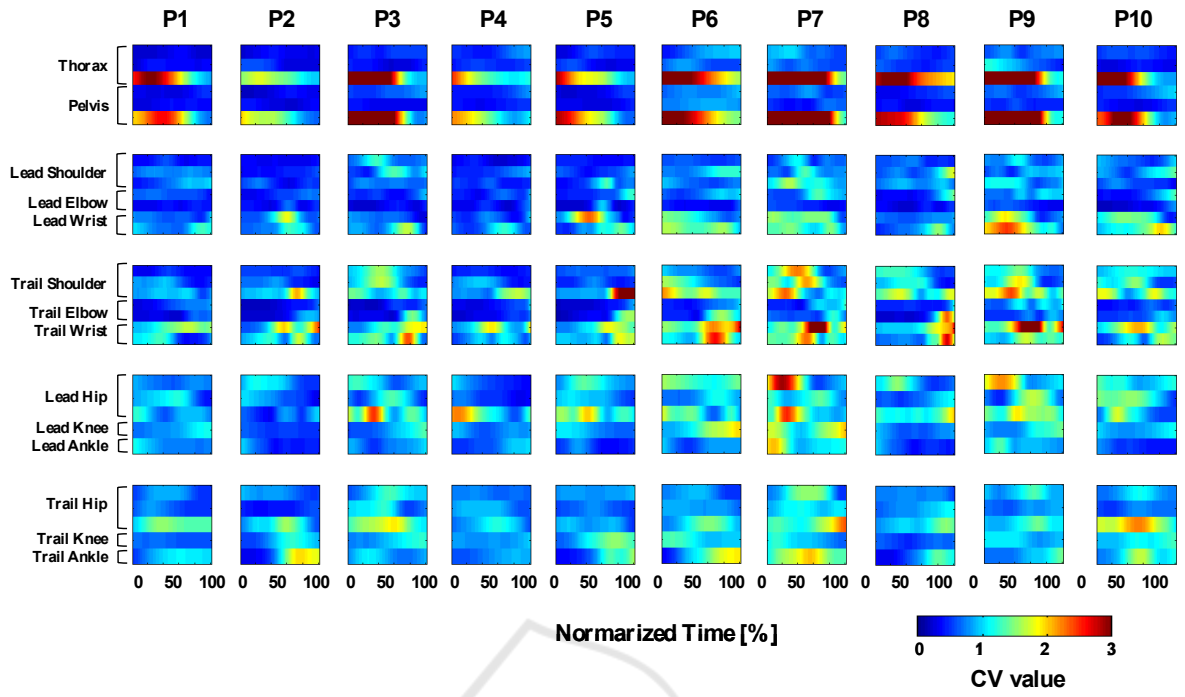

Figure 3: Visualization of coefficient of variation in forward swing phase. (Normalized time of 0 % indicates the swing initiation and normalized time of 100 % indicates the ball-bat contact).

4 DISCUSSION

A previous research demonstrated that the angles of elbow and wrist in trail arm have major change in the forward swing phase (Kawamura et al, 2008). According to this knowledge, it is considered that excessive variability of angle in trail arm may disturb the precise bat control. Therefore, hitters with lower precision in ball-bat contact might have excessive variabilities in joint angles in trail arm.

On the other hand, CV in thorax and pelvis rotation showed medium or higher value in early to intermediate phase of swing regardless of the index of precision in ball-bat contact. This result suggests that variability of thorax and pelvis rotation in early phase of the swing is less critical to hitting precision.

Earlier studies showed that hitting kinematics varies with skill level and age of players (Escamilla et al, 2009; Inkster et al, 2010). Therefore, further studies are required to investigate the hitting kinematics relating precision at ball-bat contact in various skill levels and ages.

ACKNOWLEDGEMENTS

We would like to appreciate for the all participants and experimenters of this study. Additionally, we would like to thank Haruka Shoda, for his invaluable advices on the visualization of results in this research.

REFERENCES

Higuchi, T., Nagami, T., Morohoshi, J., Nakata, H., Kanosue, K., 2013. Disturbance in hitting accuracy by professional and collegiate baseball players due to intentional change of target position. *Perceptual and Motor Skills, 116*(2), 627-639.

Morishita, Y., Hirano, Y., Yanai, T., 2015. Mechanical factors for determining the bat-head speed and the orientation of the bat at ball impact in baseball hitting. *Japanese Journal of Biomechanics in Sports and Exercise, 19*(4), 201-215.

Welch, C., Banks, S., Cook, F., Draovitch, P., 1995. Hitting a baseball: a biomechanical description. *Journal of Orthopaedic and Sports Physical Therapy, 22*(5), 193–201.

Escamilla, RF., Fleisig, GS., DeRenne, C., Marcus KT., Claude TM, Rodney I., Edward B, James RA., 2009. A comparison of age level on baseball hitting kinematics, *Journal of Applied Biomechanics, 25*(3). 210–218.

Inkster, B., Murphy, A., Bower, R., Watsford, M., 2011. Differences in the kinematics of the baseball swing

between hitters of varying skill. *Medicine and Science in Sports and Exercise, 43*(6), 1050-1054.

Kawamura, T., Shimada, K., Takahashi, K., Morimoto, Y., Koike, S., Ae, M, 2008. Comparison of kinematics of upper limb motion in the baseball batting between high and low groups in the bat speed. *Japan Journal of Physical Education, Health and Sport Sciences, 53*, 423–438.