

ADJUSTMENT OF THE LOWER LIMB MOTION AT DIFFERENT IMPACT HEIGHTS IN BASEBALL BATTING

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The purpose of this study was to investigate the change in the lower limb motion to three different hitting areas of the strike zone: high, middle, and low. Subjects were 10 right-handed male skilled batters of a university baseball team. Data were collected using a three dimensional automatic motion analysis system (Vicon 612). Joint angles of the lower limbs were computed. Comparison of the hitting in the high area vs. low area revealed that to hit the ball in the low area the batter adjusted the motion of the hip joint by regulating the flexion-extension angle of the both hips from the phase of the Swing start to the phase of the Impact. After that the phase of the Left upper arm parallel abduction angle of the right hip was smaller in case of the high, middle areas than the of the low area, and abduction angle of the left hip was larger in case of the high, middle areas than the low area.

KEY WORDS: three dimensional motion analysis, angular kinematics, striking.

INTRODUCTION: Many investigations of baseball batting have analyzed the techniques by which a batter hits a ball in the middle of the hitting areas (McIntyre, 1982; Messier 1985). However, since the pitching course in actual game varies, the batter has to modify and change the batting swing so that he or she reacts to various areas. There is little information of how a batter modifies the motion to various pitching courses. Tago et al. (2006) reported that in case of the high, middle hitting areas, the rotation of the shoulder at the impact phase was larger than the low hitting areas. Tago et al. (2009) indicated that in hitting a ball in the high and low areas, the batter adjusts the position of the bat by modifying shoulder and elbow angles, particularly at Left upper arm parallel (LUP) and modifies the angles in the left upper limb just before impact. The purpose of this study was to investigate the change in the lower limb motion to the different hitting areas.

METHODS: The experimental procedure and the setting were conditions similar to Tago et al. (2009). Subjects were ten right-handed batters of a university baseball team. Informed consent was collected after the explanation of the experimental procedure. Three different hitting areas were set in accordance to the rules of baseball. The batting tee commonly used during practice was used to modify hitting areas. The high

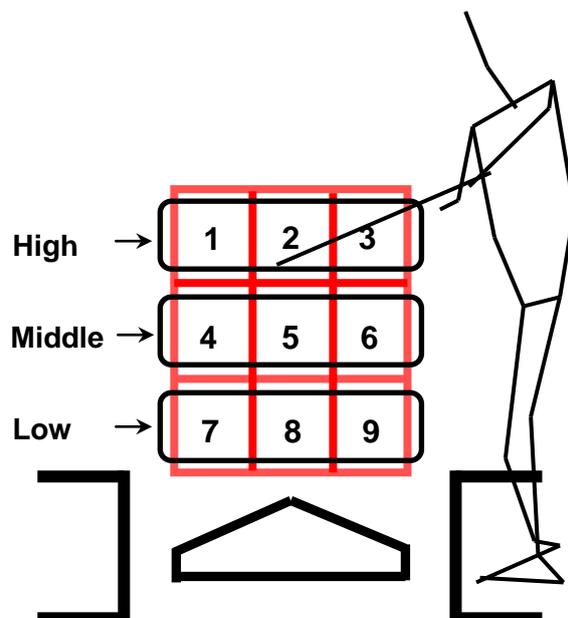


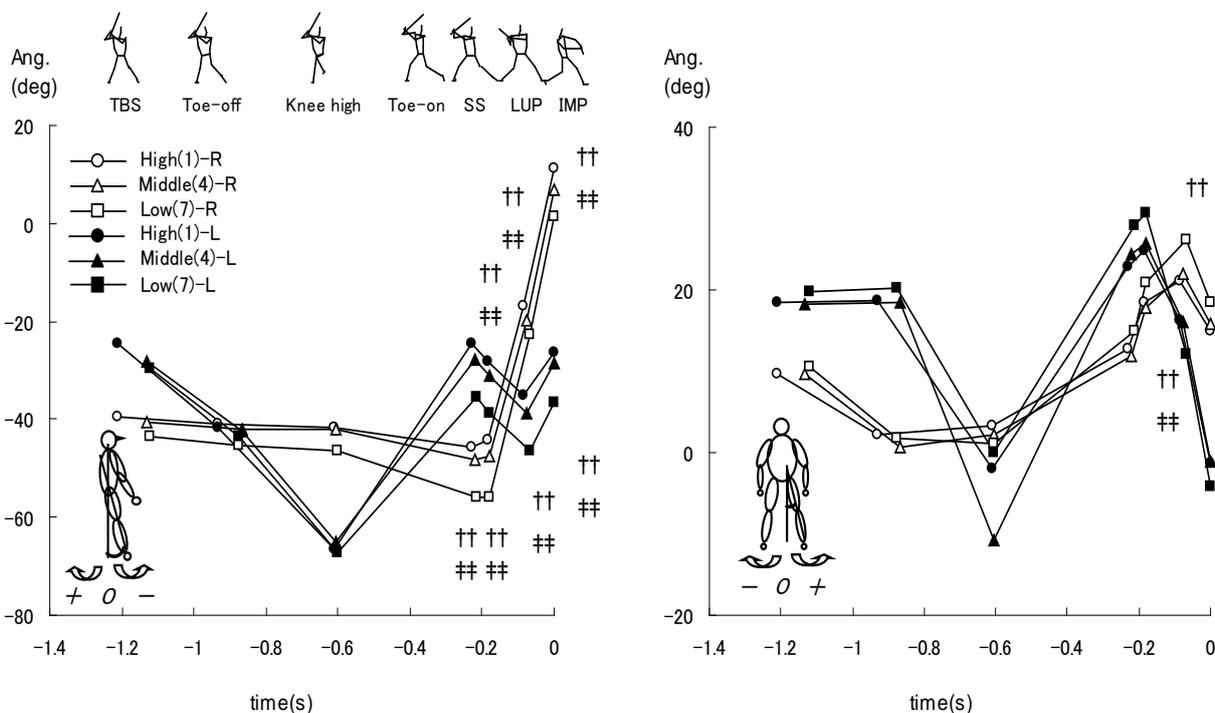
Fig.1 Hitting areas set in this study

areas for right-handed batters were defined as 1, 2, and 3 of Figure1, the middle areas as 4, 5 and 6 of Figure1, the low areas as 7, 8 and 9 of Figure1. The subjects were given the hitting areas in random order, and the position of non-stride leg was set as the same position at the beginning. The coordinate axes were defined as follows: the Y axis was set as the direction to a pitcher, the X axis as the medio-lateral direction, and the Z axis as the perpendicular direction. Data was collected by using a three dimensional automatic motion analysis system (Vicon 612). Nine cameras operating at 250Hz were used to capture the players' motion. From several trials for each point, one trial of the fastest ball velocity and the best self-evaluation was chosen in each point and subject for analysis.

For the analysis and description of data, the batting swing was divided by seven instants as follows : Start of take back (TBS): The phase at which the bat grip began to move toward a catcher. Toe-off: The phase at which the stride leg broke the contact with the ground. Knee-high: The phase at which the knee of the stride leg was in the highest position. Toe-on: The phase at which the tip of the foot of the stride leg contacted with the ground. Swing start (SS): The phase at which the bat grip began to move toward a pitcher. LUP: The phase at which the left upper arm of the batter was in parallel to the X-axis (L-upper arm parallel). Impact (IMP): The phase at which the bat contacted with the ball.

Angular kinematics computed were joint angles of the right and left ankles, knees, and flexion-extension, adduction-abduction angle of the hips. Two-way ANOVA (three heights X three courses) was used to examine the difference in the angular kinematics of the phases mentioned above between hitting areas, setting significant level at $p = 0.05$.

RESULTS AND DISCUSSION: Figures 2 and 3 show the average joint angles at seven phases during hitting in the high and low hitting areas. Figure 2-1 shows Flexion-Extension angles of the hips and Figure 2-2 shows adduction-abduction angle of the hips. In the figures,



1. Flexion-extension angle of the hip joint

2. Adduction-abduction angle of the hip joint

Fig.2 Changes in the angle of the hip joint during batting in height hitting areas.

Significant difference ($p < 0.05$) : High vs. Low ; ††, Middle vs. Low ; ‡‡

one example is shown from the present study, R indicates the right limb, L is the left limb, and, and (1),(4),(7) indicates the hitting area (Refer to Figure.1). Significant differences are shown by a symbol († † , ‡ ‡). And the definition of the each joint angle is shown in the picture in the graph.

In Figure 2-1, flexion angle of the right hip was almost constant until the phase of the SS. After that the extension angle of the right hip quickly increased toward the impact in both high and low areas. The significant difference was observed at the SS to IMP, i.e. the flexion angle of the right hip at the low area was larger than that of the high and middle areas. Flexion angle of the left hip was quickly increased until the phase of the Knee-high. After that the extension angle of this joint suddenly increased toward the impact in both high and low areas. The significant difference was observed at the Toe-on to IMP, i.e. the flexion angle of the left hip at the low area was larger than that of the high area. In Figure 2-2, abduction angle of the right hip was gradually increased from the phase of the Toe-off to the impact in both high and low areas. The significant difference was observed at the LUP, i.e. the abduction angle of the right hip at the low area was larger than that of the high area. Adduction angle of the left hip suddenly increased toward the Knee high. After that the abduction angle of this joint suddenly increased toward the SS, and again adduction angle of this joint abruptly increased toward the impact in both high and low areas. The significant difference was observed at the LUP, i.e. the adduction angle of the left hip at the low area was larger than that of the high and middle areas.

In Figure 3-1, right knee joint angle was almost constant until the phase of the IMP. However, no significant difference was observed in the seven phases in both high and low areas. The left knee joint flexed until the phase of the Knee high. After that this joint quickly extended toward the phase of the IMP in both high and low areas. However, no significant difference was observed in the seven phases in either high or low areas. In Figure 3-2, right ankle joint

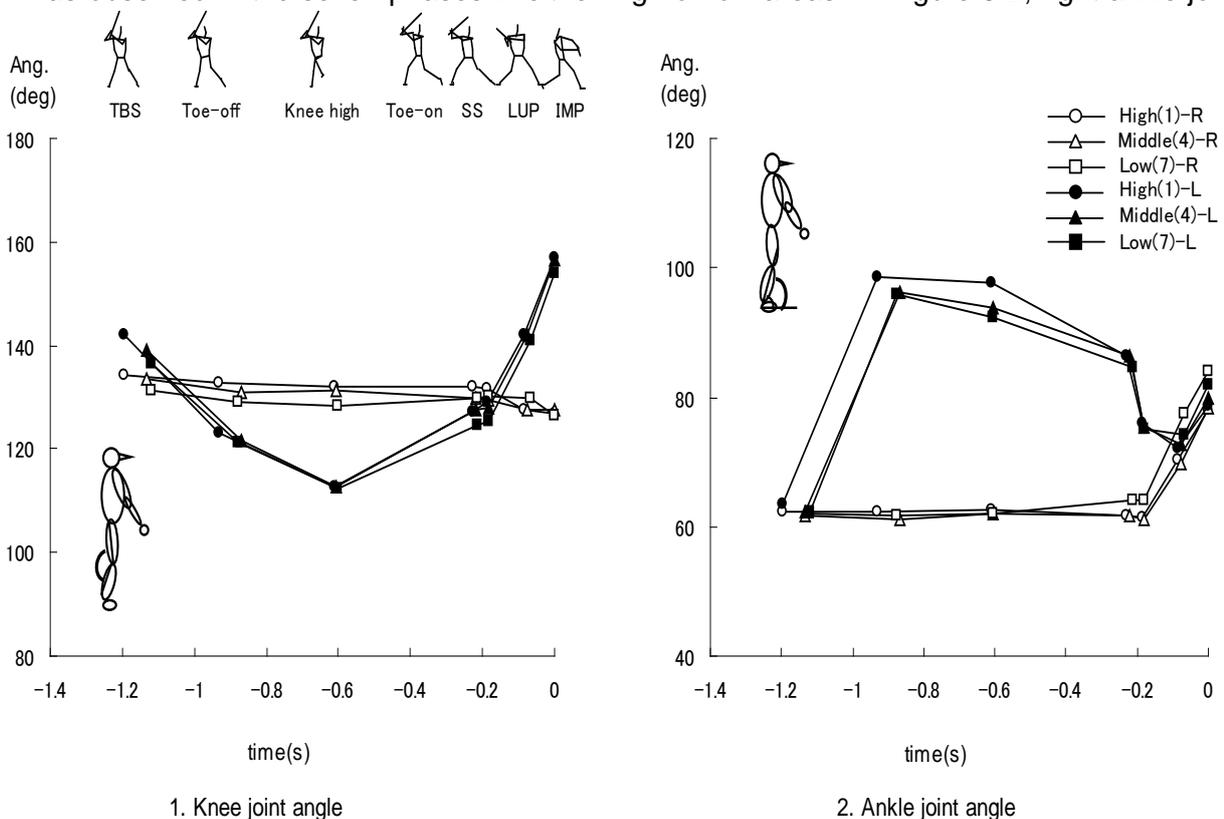


Fig.3 Changes in the angle of the knee and ankle joint during batting in height hitting areas.

was almost constant until the phase of the SS. After that this joint suddenly extended toward the phase of the IMP in both high and low areas. However, no significant difference was observed in the seven phases in either high or low areas. Left ankle joint suddenly extended until the phase of the Toe-off. After that this joint gradually flexed toward the phase of the IMP in both high and low areas. However, no significant difference was observed in the seven phases in either high or low areas.

Comparing hitting the ball in the high area with the low area, we will be able to identify that hitting a low compared with a high ball was characterized by; the batter adjusted the motion of the hip joint by regulating the flexion angle of the both hips from the phase of the SS to the phase of the IMP. At the phase of the LUP abduction angle of the right hip was smaller in case of the high, middle areas than the case of the low area, and abduction angle of the left hip was larger in case of the high, middle areas than the case of the low area. The opposite tendency to the high area was observed in the case of the low area. The significant differences in selected joint angles were observed after the commencement of the swing, which may imply that adjustments occur during the forward swing period. It was suggested that the movement of both hip joints from which a significant difference was seen in all the joint angles of the lower limb after the commencement of the swing be especially important.

CONCLUSION: In the current study the findings imply that in hitting a ball in the high and low areas, the batter adjusts the motion of the hip joint by modifying the flexion-extension angle of both hips from the phase of the SS to phase of the IMP, and the adduction-abduction angle of the both hips at the phase of the LUP, particularly the movement of the both hips since the phase of the SS is important.

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