KINEMATIC CHARACTERISTICS OF OPPOSITE-FIELD HITTING

Marc Gelinas

T. Blaine Hoshizaki

Introduction

Baseball is one of many popular sports in which the central event involves a collision between an implement and a ball. It is generally agreed that hitting a baseball is one of the more difficult skills to learn in sport (Breen, 1975; Williams & Underwood, 1971).

In addition to the habitual goal of maximal transfer of momentum to the ball, the batter frequently faces problems of directional guidance, due to certain strategic and mechanical requirements. The nature of the contact surfaces, the high velocity of pitched baseballs and the variety of ball trajectories combine to increase the difficulty of the task.

Review of Literature

Several investigators have studied hitting without concern for the direction in which the batted baseball travels (Breen, 1967; Kitzman, 1964; Puck, 1964; Race, 1961; Shapiro, 1974, 1979; Swimley, 1964). However, achieving optimal transfer of momentum is a primary batting objective requiring different positioning of the bat in relation to the ball. This orientation of the bat serves to minimize the deviation of the contact point with the bat's center of percussion, thus reducing the energy lost during impact and the undesirable vibration felt in the batter's hands.

The motion of the bat can be described as occurring in two phases, the first being the change in position from a vertical to a horizontal orientation of the long axis of the bat. The second phase is characterized by the rapid rotation of the bat in the horizontal plane, into the contact area (Shapiro, 1979).

The position of the bat at impact is controlled by complex, coordinated sequential applications of joint torques, proceeding from the ground, to the forearms and hands. The movements involved in the swing thus proceed in a sequential fashion, with the hips, shoulders, arms, and finally the hands and bat being driven forcefully around to the front.

The ability to project the batted ball to selected area of the playing field is recognized as a distinguishing factor in batting effectiveness (Williams & Underwood, 1971). In light of the importance given to the ability to hit the ball to the opposite-field, it is surprising to note that little scientific attention has focused on the kinematic characteristics of opposite-field hits.

It appears that the angle of incidence between the bat and path of the pitched ball is the primary means by which the ball is hit to different field areas (Bunn, 1972; Hay, 1978), and that angular displacements observed in same and opposite-field hitting follow similar patterns. (Pfautsch, 1980). The appropriate angle of incidence for an opposite-field hit is produced by modifying the swing so that: (1) the hands are ahead of the point of contact with the ball, (2) adduction of the front wrist is restricted, and (3) the lead elbow is not allowed to fully extend (Pfautsch, 1980; Williams & Underwood, 1971). Further, the coaching literature suggests that the amount of hip rotation is related to the field area in which the ball is to be directed, and that a smaller amount of hip rotation is necessary to hit the ball to the opposite-field (Weiskopf, 1968).

The purpose of this study was to investigate the kinematic patterns characterizing the same (SF) and opposite-field (OF) hits performed by an elite baseball player.

Methods

Subject

The subject was a 35-year old, 13 year Major League professional player, rated as an efficient opposite-field hitter by his coaches. Several landmarks were fixed onto the subject at segmental end-points and on the bats being used. A belt was specifically designed to allow quantification of hip rotation during the execution of the swings.

Cinematographical Techniques

The assumption was made that the movements of interest occurred primarily in the horizontal plane. Hence, a high-speed Redlake Locam camera was nominally set at 200 fps, and positioned

4.62m above the filming area so that its optical axis was perpendicular to the horizontal plane. The camera was loaded with color Kodak 4X reversal film (type 7277), ASA 250.

Experimental Design

The field was equally divided into three areas: (1) opposite-field (right), (2) same-field (left) and (3) a neutral zone (center field).

The subject batted balls launched by a CASEY pitching machine, released 17.1m from the front edge of home plate. The velocities of each of ten test pitches were confirmed by a DECATUR radar gun, resulting in a mean value of 33.5 m/s, slightly lower than reported values for Major League fastballs (35.9 m/s, Atwater, 1977). The pitching machine was adjusted to account for the lack of visual cues usually available to the batter.

After a typical warm-up routine, the subject alternately performed four series of 12 consecutive trials to the same and opposite-fields, for a total of 48 trials. Each trial was subjectively evaluated. In all, 24 trials were retained for analysis. These included ground balls, line drives and fly balls stroked firmly into the desired field area. Balls landing in the neutral zone were excluded from analysis, as it was felt that such trials may incorporate characteristics of both types of field hits.

Results

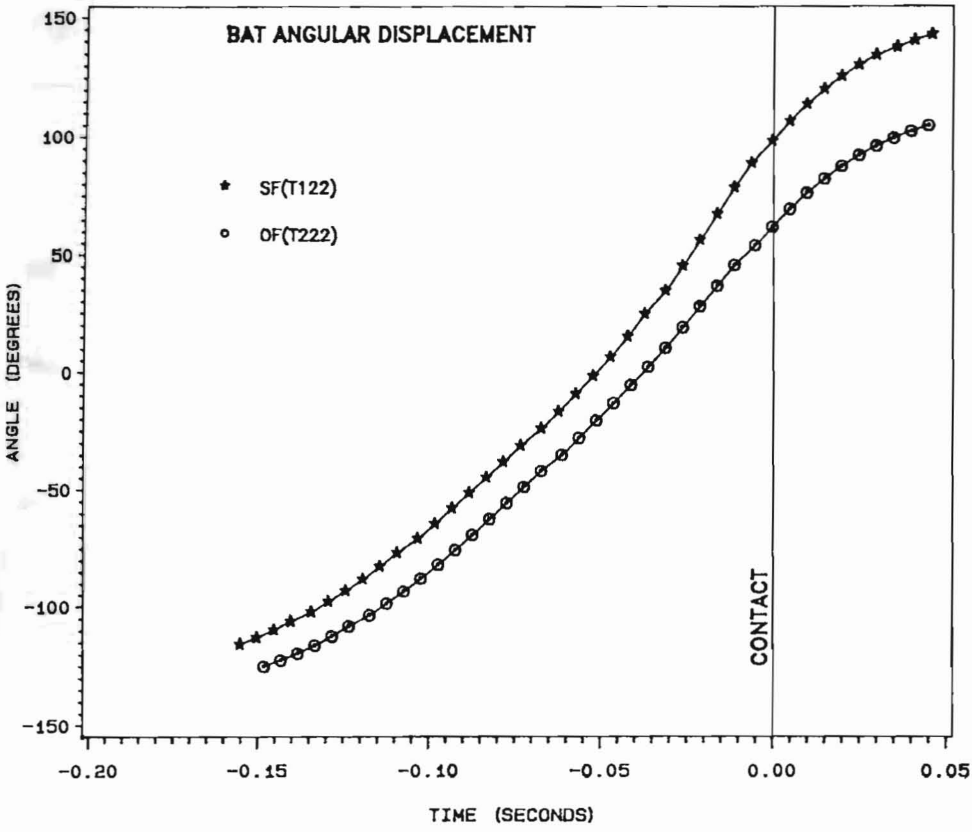
All angles were measure in the horizontal plane, with absolute values being relative to a straight line joining the middle of the pitching rubber with the middle of home plate. Mean angles (measured at contact) were compared, and the statistical results are reported in Table 1.

Table 1. Comparative statistics of the execution of the two types of field hits at contact (in °, Mean ± SD) * = $p < 0.05$

Variable	SF (n=14)	OF (n=8)	T	p
BAT	103.3* (8.3)	73.1 (10.3)	7.53	0.000
HROT	67.5* (6.9)	53.3 (5.0)	5.07	0.000
SROT	62.2* (8.1)	51.2 (9.0)	2.93	0.016
LSAN	83.3 (16.3)	85.3 (10.5)	-0.31	0.761
LEAN	144.5 (18.5)	147.0 (13.9)	-0.33	0.744
LBFAN	157.3* (4.8)	137.9 (6.9)	7.71	0.000

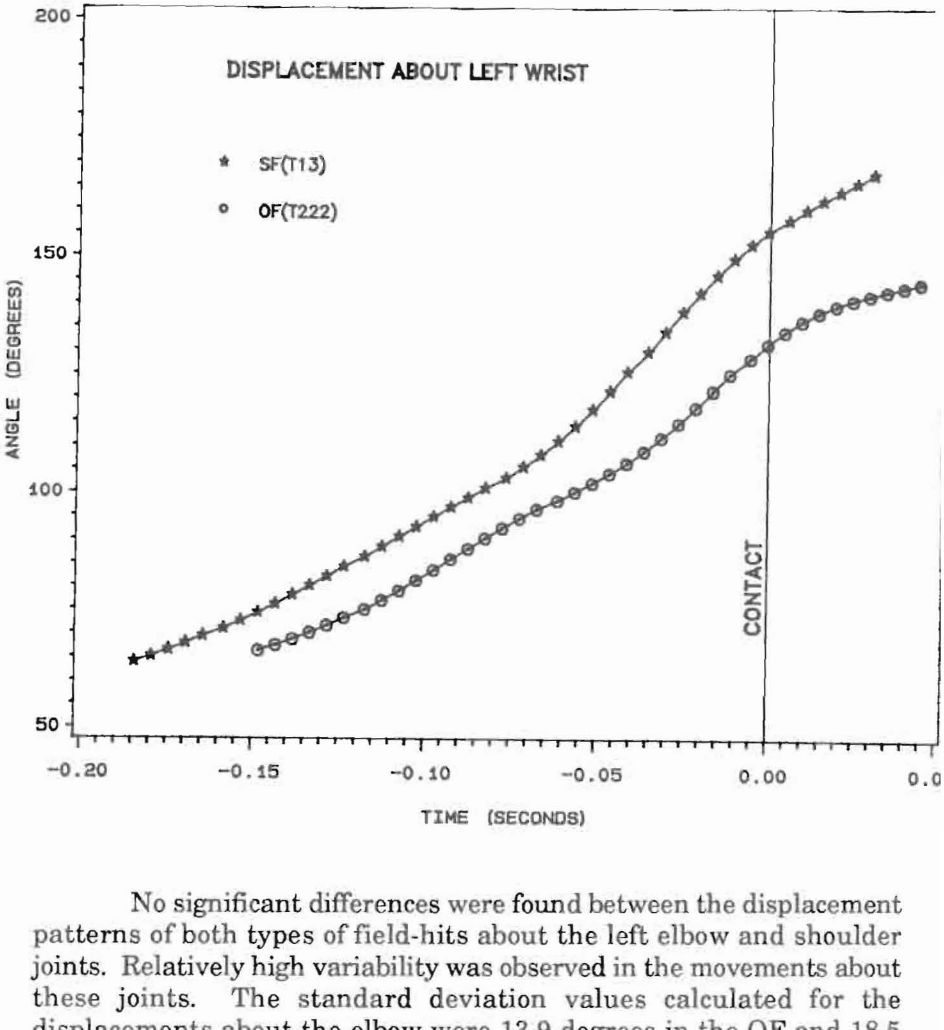
SF : same-field hit
OF : opposite-field hit
BAT : bat [angle]
HROT : hip [angle]
SROT : shoulder [angle]
LSAN : left shoulder angle
LEAN : left elbow angle
LBFAN : bat-forearm angle
T : T score
P : probability of T

Expectedly, independent t-tests (alpha = .05) revealed that the opposite field (OF) hits were characterized by significantly smaller bat angular displacements at contact. Figure 1 illustrates representative bat angular displacement patterns observed in both conditions. The mean angles at contact with the ball were 73.1 degrees for the OF hits, as compared to 103.3 degrees for the same-field(SF) hits.



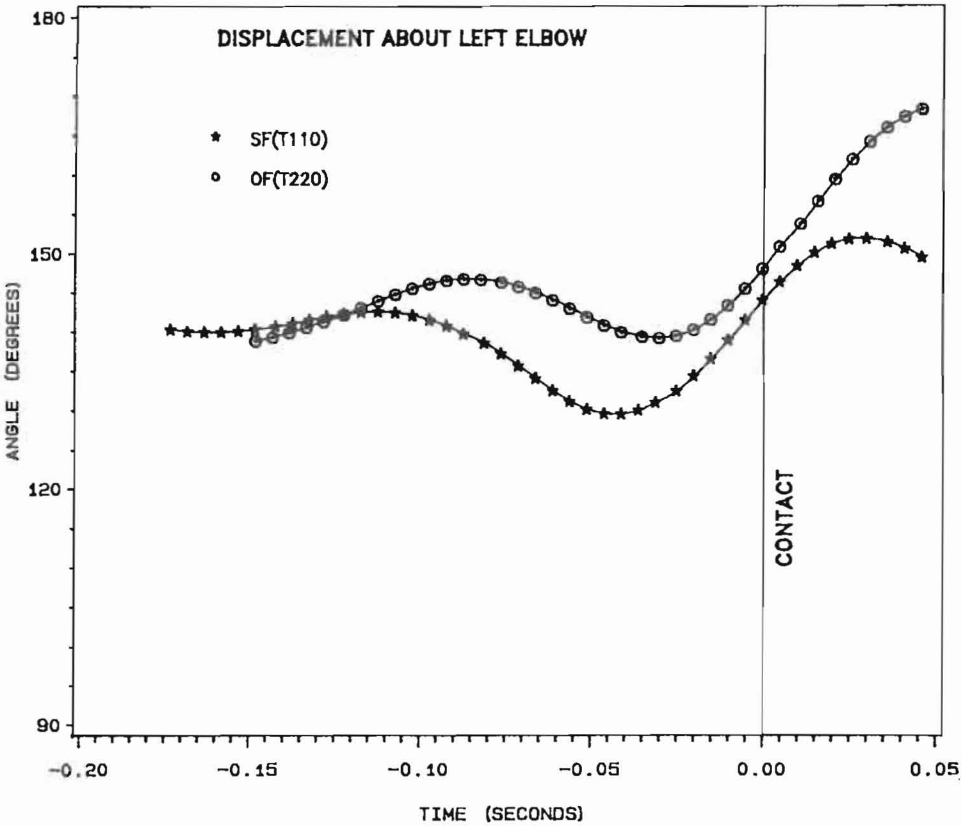
As shown in Table 1, opposite-field hits were produced through three modifications to the batting swing. The subject significantly restricted (1) the angular displacements about the left bat-forearm joint, as well as the (2) amount of hip and (3) shoulder rotation when performing the OF hit.

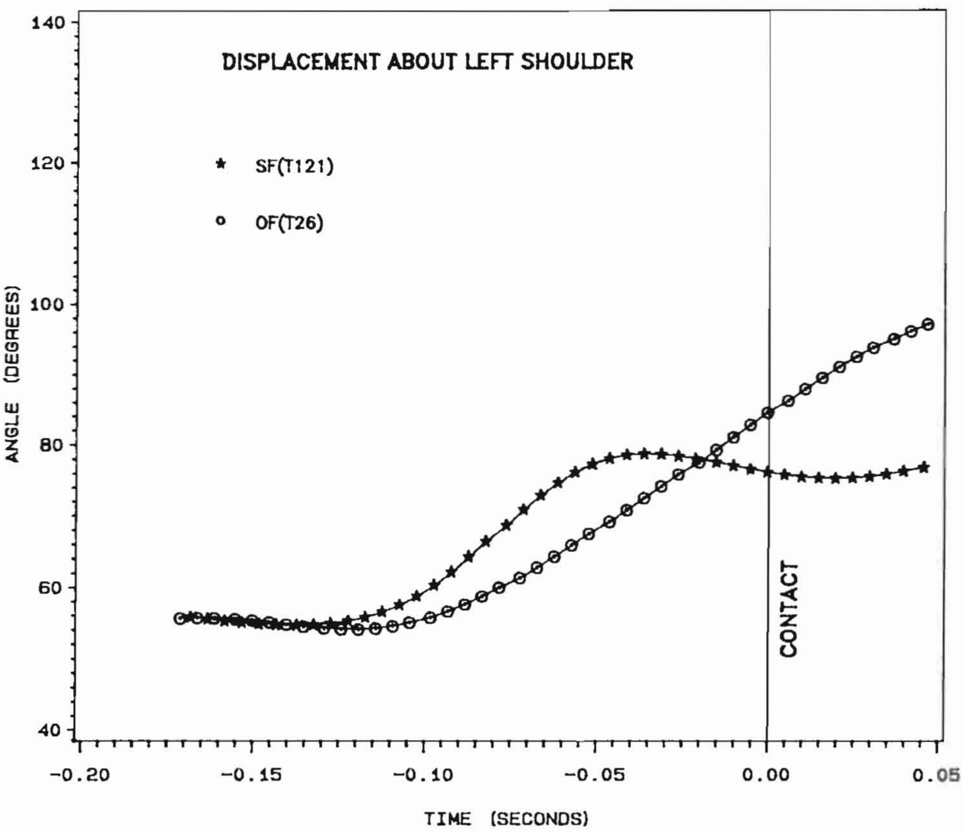
Figure 2 depicts the typical angular displacements about the left bat-forearm joint during the execution of both types of field-hits. The angles measured about the left bat-forearm joint (OF: 137.9 degrees, SF: 157.3 degrees) were significantly different, as reported earlier (Pfautsch, 1980).



No significant differences were found between the displacement patterns of both types of field-hits about the left elbow and shoulder joints. Relatively high variability was observed in the movements about these joints. The standard deviation values calculated for the displacements about the elbow were 13.9 degrees in the OF and 18.5 degrees in the SF hits. At the left shoulder joint, these values were 10.5 degrees in the OF and 16.3 degrees in the SF groups respectively. Figures 3 and 4 illustrate representative movement patterns observed about those joints.

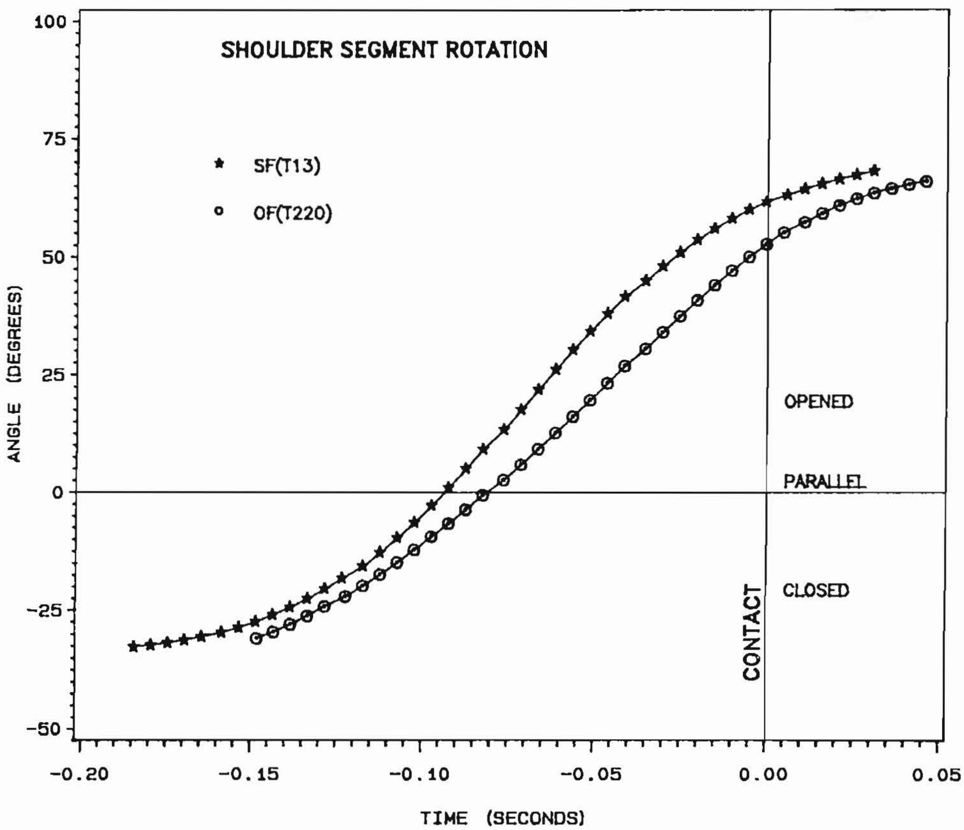
Figure 3


DISPLACEMENT ABOUT LEFT ELBOW
SF(T110)
OF(T220)
CONTACT
ANGLE (DEGREES)
180
150
120
90
-0.20
-0.15
-0.10
-0.05
0.00
0.05
TIME (SECONDS)

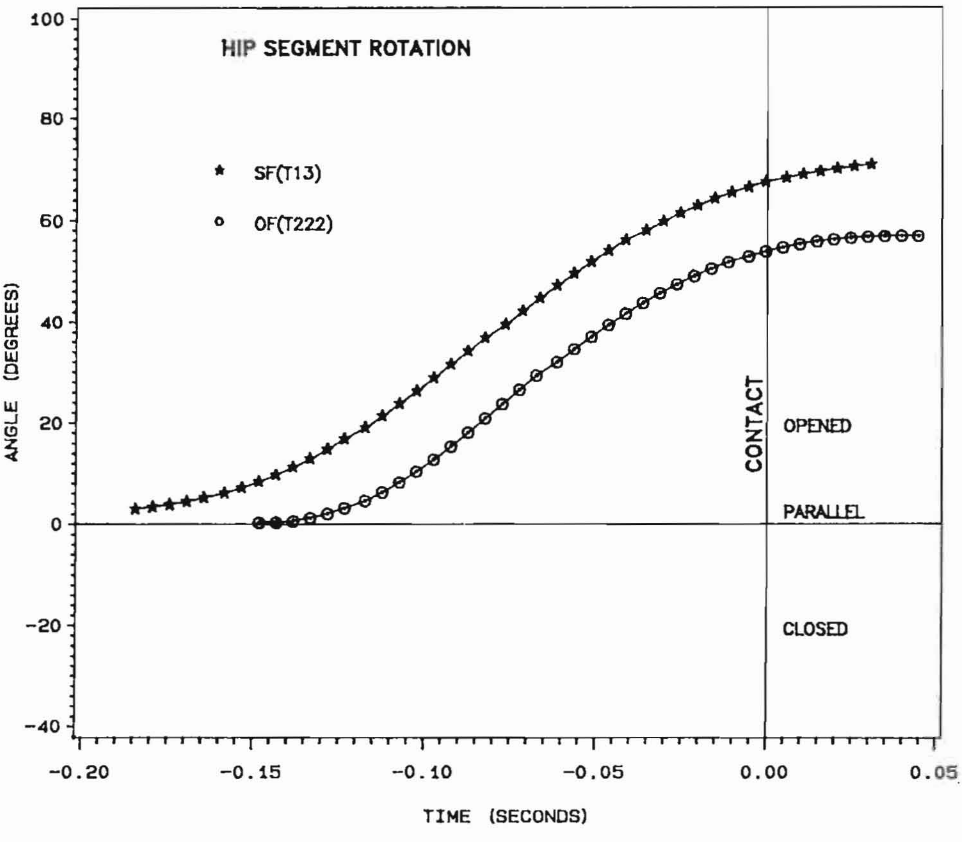


As reflected in Figures 5 and 6, the subject performed the OF hits with significantly less shoulder (OF: 51.2 degrees, 62.2 degrees) and hip segment rotation (OF: 53.3 degrees, SF: 67.5 degrees). This corroborates previous observations reported in the coaching literature (Weiskopf, 1968).

Figure 5



SHOULDER SEGMENT ROTATION
SF(T13)
OF(T220)
OPENED
PARALLEL
CLOSED
CONTACT
ANGLE (DEGREES)
TIME (SECONDS)
100
75
50
25
0
-25
-50
-0.20
-0.15
-0.10
-0.05
0.00
0.05



Discussion

The subject had to adapt to slightly different batting conditions in each trial: (1) pitch velocity, (2) vertical and horizontal location of each baseball, (3) effects of the wind, and finally (4) inconsistencies in the timing of each ball's release from the machine.

The movement pattern controlling the trajectory of the bat through the contact zone is a result of the coordinated action of the involved segments. The high number of degrees of freedom inherent in such motor tasks allow fine adaptations fo each hitting condition. It is therefore probably that the high variability noted about the left elbow and shoulder joints is a reflection of their responsibility in satisfying the directional objective while coping with various environmental constraints.

In summary, this study was concerned with those situations in which the batter knew what type of field-hit to attempt. on the basis of the results of this study, it appears that for opposite field hitting, the batter restricts the adduction of the left hand, and the amount of hip and shoulder segment rotation to ensure proper orientation of the bat at contact with the incoming pitch. Additional adjustments may also be made at the left elbow and shoulder joints, to adapt the swing in order to make optimal contact with the ball.

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