An Analysis of Timing in Softball Hitting

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Abstract

The purposes of this study were to determine the time when female softball hitters started to shift the center of gravity of the body (CG) and to examine how they reacted to the changing speed of a pitched ball. Four female softball hitters, 2 skilled (S) and 2 unskilled (U), participated in this study. A female softball pitcher was requested to throw an official ball at each one of three rates of ball speeds (fast, medium, and slow), which were randomly delivered to a hitter. In order to record the ground reaction force exerted by each foot, subjects were requested to put one of their feet on each of two force-platforms. At the same time, hitting motion was filmed from the front by a cine-camera (100 fs/sec). Pitched ball speed (BS) (m/sec), duration of swing (ST) (sec), and the speed of a bat (BtS) (m/sec) were calculated from the cinematographic data. It was shown that the skilled tended to have slightly shorter ST than the unskilled. No significant correlation coefficient was found between ST and BS among all subjects, whereas the skilled showed greater BtS. Each foot force applied on a respective force-platform in the pitcher-catcher direction (F) was used for the analysis of timing. Using the obtained force curves, following calculations were made ; 1) duration from X to impact (X-IP) (sec), in which X was designated at the point from where the piled F curves branched out, 2) distance from the position of a ball at X to that at the impact : (BP)(m) = BS(m/sec) × X-IP(sec). The values of X-IP were 0.42±0.093 sec for S1, 0.36±0.011 sec for S2, and 0.34±0.083 sec for U1, respectively. The skilled tended to have longer X-IP. It was also found that the greater BS was, the shorter X-IP the all subjects had. However, there was no correlationship between BP and BS. In order to clarify the pattern of F at each BS, F curves were piled using the impact point as a trigger. In the skilled, the pattern was varied before the start of swing but it was almost the same after the onset of swing. On the contrary, the unskilled showed almost the same pattern before starting the swing but it varied after starting the swing.

Key Words ; softball hitting, ground reaction force, analysis of timing.

Introduction

It has ever been stated that hitting a ball in all sports is one of the most difficult skills to master, for hitting has two aspects, i. e. sensory-perception and motor-response, and a hitter must integrate those in a short time. The former aspect consists of eye-body coordination. In tracking a pitched ball visually, a hitter must predict the locus of the ball and at a certain point in its flight one has to decide whether to swing at or not. Furthermore, if one decides to swing, he or she must adjust exact point of time when he or she starts his or her hitting motion in response to the ball speed, namely, with proper timing. On the other hand, the latter aspect involves body-bat coordination. By summing up the velocities of the movements of the related body segments, a hitter must generate maximal bat speed in order to hit the ball with a greater impact.

The purpose of this study was to determine the time when female softball hitters started to shift the center of gravity of the body (CG) and to examine how they reacted to the changing speed of a pitched ball.

Table 1. Subjects' physical characteristics and hitting careers.

Subj.	Sex	Age (yrs)	Ht (cm)	Wt (kg)	Hitting Ave.
S 1	F	21	156.0	54	0.286
S 2	F	20	170.0	66	0.292
U 1	F	18	159.4	53	...
U 2	F	19	164.6	66	

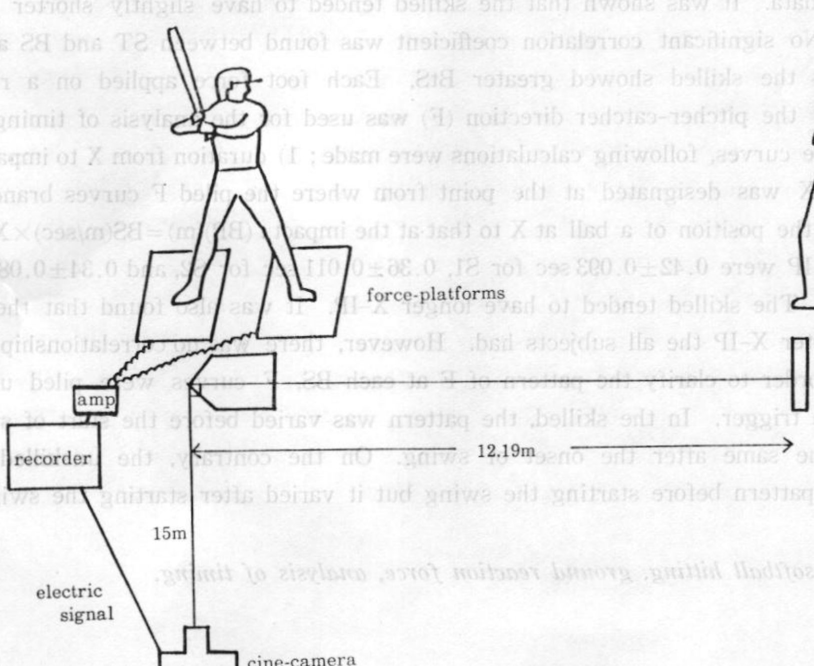

Fig. 1 Experimental setup

Procedure

Four female softball hitters, 2 skilled (S) and 2 unskilled (U), participated in this study. The skilled were the players who regularly played in an intercollegiate softball league, while the unskilled were not playing in any official games but belonged to a college softball team. They provided their informed consents. The subjects' physical characteristics and hitting careers are presented in Table 1.

A female softball pitcher was requested to throw an official ball (177.19–198.45 g) in a manner determined by rule at each one of three rates of ball speeds (fast, medium, and slow), which were randomly delivered to a hitter. In order to record the magnitude and direction of the ground reaction forces exerted by each foot, subjects were requested to stand on two force-platforms (Kistler Co.), the left leg on the pitcher's side and the right leg on the catcher's side. At the same time, hitting motion was filmed from the front by a cine-camera (100 fs/sec, Photosonics 16-1P) (Fig. 1). Film and force-platform data were syncronized by an electric signal.

Each subject tried to hit a ball about 15 times. In all trials, evaluation of timing in hitting (early, proper, and late) was made by two experts in softball so as to select hitting trials with proper timing for analytical use.

Following items were calculated from the cinematographic data obtained.

1. pitched ball speed immediately before impact (BS) (m/sec)
2. duration of swing from the onset of the forward movement of a bat to its impact on the ball (ST) (sec)
3. the speed of a bat (its head part) immediately before the impact (BtS) (m/sec)

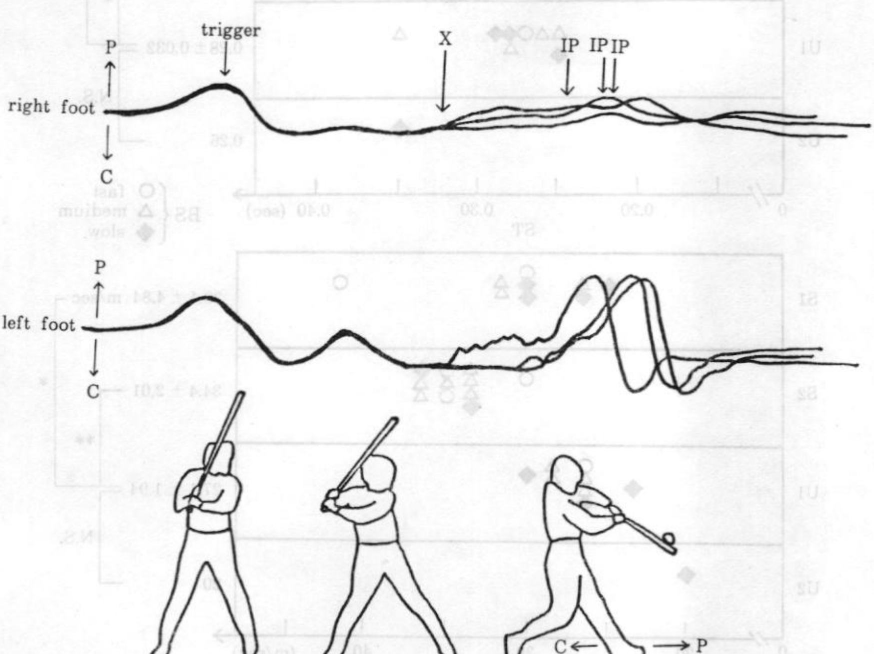

Fig. 2 The ground reaction forces exerted by each foot. X represents the point at which piled F curves begin to separate.

Each foot force applied on a respective force-platform in the pitcher-catcher direction (F) was used for the analysis of timing. Using the obtained force curves which were syncronized with cinematographic data, following calculations were made.

1. duration from X to impact (X–IP) (sec), in which X was designated at the point from where the piled F curves branched out (Fig. 2).
2. distance from the position of a ball at X to that at the impact, in which following equation was used ; BP(m) = BS(m/sec) × X–IP(sec).

Results

Three rates of BS delivered by pitcher were significantly different ($p<0.01$) from one an-

Table 2. Pitched ball speed (BS)

	fast	medium	slow
BS (m/sec)	22.83* ±2.46	18.18 ±1.62	14.39* ±1.39

mean ± s. d.
*; $p<0.01$ when different from the medium ball speed.

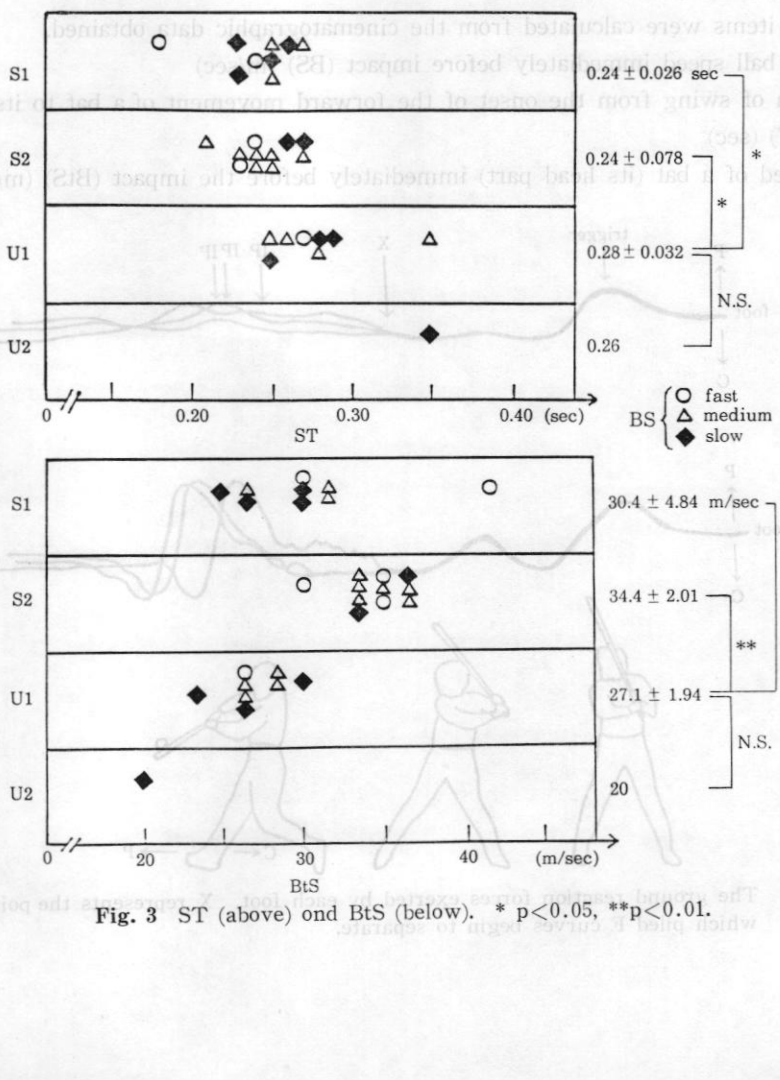

Fig. 3 ST (above) ond BtS (below). * $p<0.05$, ** $p<0.01$.

other (Table 2). Therefore, it was considered that the pitcher could throw the ball at the designated speed at her own will.

All subjects, excluding U2 who hit the ball with proper timing only once, hit the ball properly by 50–70% of all trials.

Duration of swing (ST) is presented in Fig. 3. It was shown that the skilled (S1, S2) tended to have slightly shorter time than the unskilled (U1, U2). No significant correlation coefficient was found between ST and BS among all subjects, whereas the skilled showed greater bat speed (BtS).

Typical foot force curves obtained from the left and the right foot for each group of subjects are shown in Fig. 4. As illustrated in the figure, duration of time between point X and the impact (X–IP) was measured. The values obtained were 0.42 ± 0.093 sec for S1, 0.36 ± 0.011 sec for S2, and 0.34 ± 0.083 sec for U1, respectively. The skilled tended to have longer X–IP. It was also found that the greater BS was, the shorter X–IP the all subjects had. However, there was no correlationship between the position of pitched ball from the impact at point X

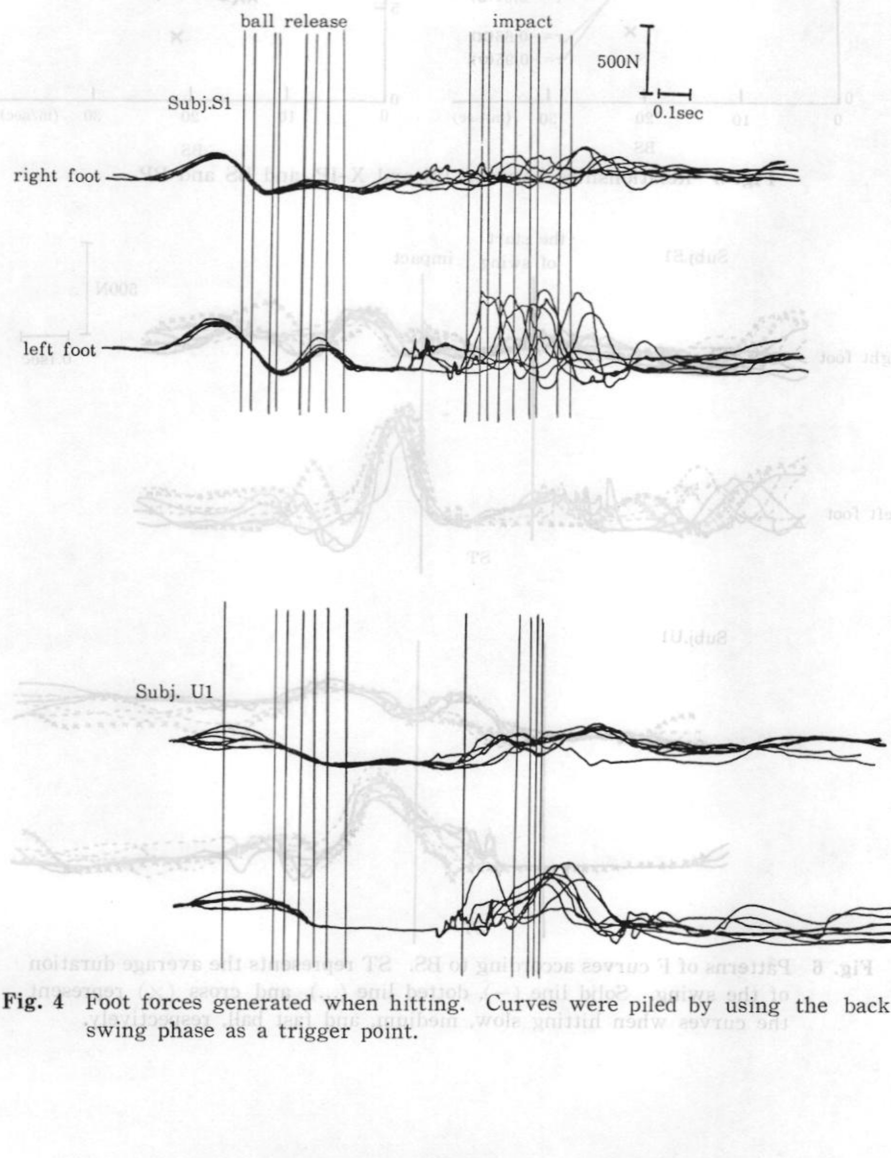

Fig. 4 Foot forces generated when hitting. Curves were piled by using the back swing phase as a trigger point.

(BP) and BS.

In order to clarify the pattern of F at each BS, F curves were piled up using the impact point as a trigger. In the skilled, the pattern was varied before the start of swing but it showed almost the same pattern after the onset of swing. On the contrary, the unskilled showed almost the same pattern before starting the swing but it varied after that.

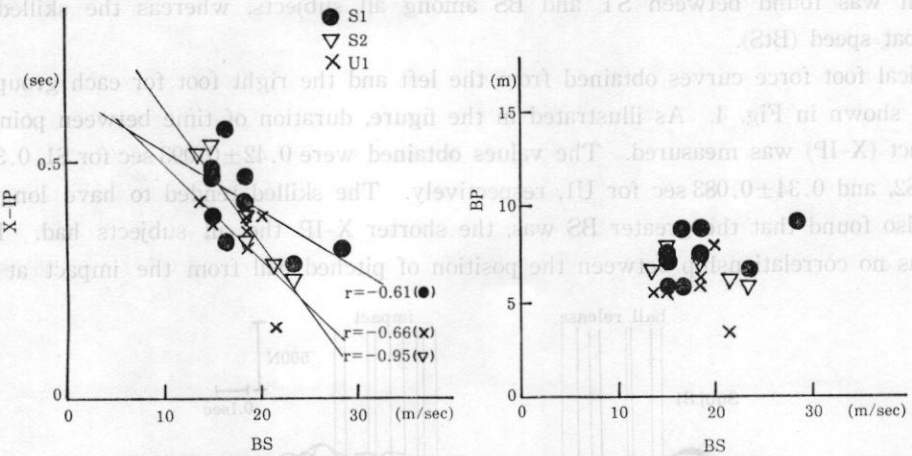

Fig. 5 Relationships between BS and X-IP, and BS and BP.

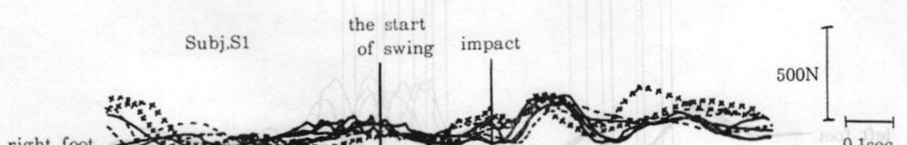

Fig. 6 Patterns of F curves according to BS. ST represents the average duration of the swing. Solid line (−), dotted line (...), and cross (×) represent the curves when hitting slow, medium, and fast ball, respectively.

Discussion

In this study, it was found that in the skilled players the changes in F began to appear sooner in the locus of the pitched ball than in the unskilled. It seemed to suggest that the skilled could differenciate BS earlier and could adjust the movement of CG to BS more adequately than the unskilled. On sensory-perceptual problem of hitting, the reaction time, which is the time between the presentation of visual stimulus and the beginning of the bat swing, has always been the point of argument. When investigating reaction time in swinging to a given stimulus, Slater-Hammel, A. T. et al. reported the values of 0.206 sec as simple reaction time[9] and 0.293 sec as choice reaction time[10]. According to Breen, J. L.[1] and Race D. E.[6], swinging of a bat lasted 0.19–0.28 sec. Therefore, it might be estimated that the total time required in swinging would be the sum of reaction time and swinging time, i.e. the total of 0.4–0.5 sec. In considering very short flight time of the pitched ball from the mound to the home plate, which is 0.43–0.58[7], a hitter must predict the course and the speed of the ball immediately after the release of the ball by the pitcher. Hubbard, A. W. et al.[3] asserted that in hitting situation the hitter's step and "wind up" for the swing must occur while the sensory-perceptual process was under way. Glencross, P. L. et al.[2] also claimed that hitter must anticipate the direction and position of the ball very early in its flight, and that hitter would have to initiate part of the swing prior to delivery.

In following the line of these assertions, as the skilled in this study started their swinging movement earlier, they were said to be taking good stance in hitting a ball properly. While in this study BP was calculated by using the ball speed immediately before the impact and it was found to be at 5–8 m from the impact, i.e. at about a half way between the pitcher's mound and the home plate, the actual BP at which swing motion started may be considered a little further than that from the impact. Therefore, in this study it was suggested that a hitter was not judging the ball speed immediately after the release of the ball.

In the skilled, F was reconformed before the start of swing, and as reported by Messier, R. G. et al.[4], a rapid increase in bat velocity directed toward the pitched ball began 0.12 sec prior to the contact point. Therefore, it was considered that the skilled did control their CG continuously before starting the swing. Although they started to shift their CG sooner than the unskilled, when hitting off-speed pitches, they appeared to once lift and then land their left foot and decelerate the movement of their CG so that proper timing might be maintained throughout the swing.

The skilled showed desirable body control before the start of swing and almost the same pattern of F was maintained in spite of changes in BS after starting the swing. Their left foot seemed to be firmly landed when they tried to make a good impact on all types of pitches. It was considered that, in doing so, they generated greater BtS. On the contrary, the unskilled showed different pattern of F during their swing, with which they frequently hit the ball late. So, it was considered that, even if they had proper bat control, they seemed to be considerably sacrificing their BtS.

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