A CINEMATOGRAPHIC STUDY OF THE SINGLE LEG CLEAR AS EXECUTED BY THE GOALKEEPER IN FIELD HOCKEY

Thesis for the Degree of M. A.

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SUSAN J. BUCKLEY

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By

Susan J. Buckley

AN ABSTRACT OF

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements

MASTER OF ARTS

Department of Health, Physical Education and Recreation

1968

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ABSTRACT

A CINEMATOGRAPHIC STUDY OF THE SINGLE LEG CLEAR AS EXECUTED BY THE GOALKEEPER IN FIELD HOCKEY

by Susan J. Buckley

This study compares joint velocities of the right shoulder, knee, ankle, and toe of a novice and a skilled goalkeeper. Very few articles have been written on the goalkeeper position in field hockey, and those that have been written are based upon assumption, observation, and experience.

Three 16-mm Bell and Howell cameras with a maximum speed of 64 frames per second were used for taking pictures. One camera was placed directly in front of the subject, one directly to the side of the subject, and one directly above the subject. Two subjects were filmed, one novice and one skilled goalkeeper. Both subjects were taped according to the technique described by Glassow. For the purpose of synchronization of the films, all three cameras filmed a ball rolling down a short wooden ramp before each clear was executed. Time per frame was calculated by the ball drop method. A Bell and Howell Time and Motion Analyzer projector was used to analyze the films. Velocities of each joint measured were calculated and graphed.

After analyzing the front, side, and top films through the use of velocity curves, the following conclusions have been drawn. Peak velocity of the ankle and toe should be reached before ball contact. The body weight should be kept forward, over the stationary leg, during ball contact. The ankle and toe should rotate away from the ball, or be in a "cocked" position, before rotating toward the ball. The clearing foot should rise slightly in order to contact the ball at its center of gravity. In the single leg clear, the desired direction of the cleared ball is to the side; and therefore, the direction of movement of the clearing toe should be to the side and forward rather than completely forward.

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ACKNOWLEDGEMENTS

I wish to express appreciation for the assistance rendered me while working on this thesis.

I would like to thank Dr. William W. Heusner for aiding me in writing my thesis; Dr. Harriet Stewart and Mary C. Parker for their help in filming the subjects; and to Pat Davis who demonstrated her ability as the skilled goalkeeper in the films.

S. J. B.

DEDICATION

I wish to dedicate this thesis to

DR. HARRIET STEWART

who gave me the inspiration for
this thesis and who aided me greatly
in its beginning

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Field hockey is becoming an increasingly popular sport for girls and women. It is played in public and private schools, colleges and universities, and in clubs and associations throughout the United States. There are eleven players on a field hockey team, each one contributing toward a team effort. Most books written on field hockey actually deal with only ten players and then add a brief statement about the goalkeeper. Most people writing about field hockey know very little about the goalkeeper position. To be effective, a goalkeeper needs to know specific skills, how and when to use them, and team strategy. The goalkeeper must acquire confidence in her ability to perform these skills. There are many techniques used to clear a shot for goal; but in this study, the writer is concerned only with the single leg clear to the left. This study was undertaken to satisfy the writer's curiosity regarding the mechanics of the single leg clear. It is also hoped that this study will answer many questions for both coaches and players.

Purpose of the Study

The purpose of this study was to compare joint velocities of the right shoulder, knee, ankle, and toe of a novice and a skilled goalkeeper.

Need for the Study

Little information is available on the goalkeeper position, and this information is based only upon assumption and observation. The single leg clear is an important skill used by the goalkeeper in field hockey, and the mechanics of this skill need to be known by both players and coaches.

Limitations of the Study

The greatest limitation of this study was the number of subjects that were filmed. Skilled subjects available for filming were very limited; however, the writer felt very fortunate to have been able to film Pat Davis who was given an Honorable Mention at the National Tournament sponsored by the United States Field Hockey Association in November, 1967. Only one skilled (Davis) and one novice goalkeeper were filmed. Time and expense prevented the writer from filming other subjects.

The equipment used limited the clarity of the films. Higher-powered lenses should have been used on the front and side cameras, so that these cameras could have been placed 5 to 10 feet further away from the subject to get a larger and clearer image of the subject on film. The top camera, which was resting on scaffolding, should have been 5 to 10 feet higher to get a better overview of the subject. The films were taken at 64 frames per second;

but because of fast joint actions, the films should have been taken at a faster speed to provide clearer pictures.

Published information available on cinematographic methods in physical education and on goalkeeping techniques in field hockey was very limited and provided only part of the needed information.

CHAPTER II

REVIEW OF LITERATURE

Very few articles have been written on the goalkeeper position in field hockey, and those that thave been written are unclear and contradictory. The available information is based only upon assumption, observation, and experience.

Delano (6) describes the skill as a short, quick backswing and follow-through, keeping the foot along the ground and ending the clear with the body weight over the opposite foot.

Heyhoe (9) recommends that the clearing foot contact the ball with the inside of the foot, keeping it parallel with the ground, following through after the ball, and ending with the weight forward on the kicking foot.

Elliott (7) believes that the goalkeeper should meet the ball with the inside of the big toe, keeping the foot close to the ground and kicking through the ball rather than up.

Zelley (14) feels that the ball should be met with the inside of the foot to give it direction, and that there should be little forward motion of the foot.

Samways (12) believes that the kick should be made with the inner part of the foot, and that the kicking foot should lunge forward. She also says that when clearing to

the left, the goalkeeper's right foot should swing across to kick to the left.

Lees and Shellenberger (11) recommend that the ball should be kicked with the inside of the instep, sliding the foot along the ground and keeping the knee slightly bent.

Burr (3) believes that the inside of the instep of the kicking foot should be pushed towards the ball at the last moment with the knee slightly bent and the foot sliding along the ground.

[illegible]

CHAPTER III

RESEARCH METHODS

The cinematographic techniques described by Cureton (5) and Glassow (8) were used to analyze the mechanics of the single leg clear. One novice and one skilled goalkeeper were used as subjects. Three 16-mm Bell and Howell cameras with a maximum speed of 64 frames per second were used for taking pictures. The front camera was placed 90 feet from, perpendicular to, and facing the front of the subject. The side camera was placed 90 feet from, perpendicular to, and facing the left side of the subject. The top camera was rested on a scaffolding built so that the camera would be 15 feet above the ground. The top camera was then placed directly over the subject. The front and side cameras were equipped with 75 mm lenses, and the top camera was equipped with a wide-angle lens. The front and side cameras were mounted on tripods to avoid the possibility of movement, while the top camera was steadied on the scaffolding railing. A regulation field hockey ball was rolled to the subjects to provide greater consistency of placement and velocity from trial to trial.

Analytical Procedure

Both subjects were taped according to the technique described by Glassow (8). The areas taped were the shoulder

joint, the center of the patella, the medial and lateral malleoli, and the center of the Doman kickers worn by the goalkeepers.

For the purpose of synchronization of the films, all three cameras filmed a ball rolling down a short wooden ramp before each clear was executed. The first frame in each film of a skill sequence was designated as the frame the ball contacted the end of the ramp.

Time per frame was calculated by the ball drop method. All three cameras filmed a shot put dropping from a known height. A bench reading was obtained from the filming area to get a correct numerical value for the acceleration due to gravity. By applying the law of falling bodies with known values for height and the acceleration due to gravity, time in seconds was calculated. The time represented by each frame of film from each camera was determined by dividing the total time by the number of frames used to film the ball drop by each of the three cameras.

Distances traveled by each taped point were plotted by projecting pictures on a sheet of white paper 7 feet from a Bell and Howell Time and Motion Analyzer projector. The film was cranked through the projector frame by frame. A reference point in the field of the projected image was noted in each plotting. The points were plotted from the time the left foot contacted the ground until all forward movement of the joint was completed.

The distance the joint moved, as plotted on the paper from beginning to end, was measured in 32nds of an inch by a transparent ruler. These plotted distances were then converted to real distances in the following manner. An object with a known measurement was filmed by each camera before a skill sequence was filmed. This object when projected on white paper from a distance of 7 feet was measured in each film. The real measurement then was divided by the projected measurement which provided a multiplier or a converting factor for each film. Every measurement taken from the films then was multiplied by this factor to bring the measurement up to true size. Velocities of each joint measured then were calculated and graphed.

CHAPTER IV

MECHANICAL ANALYSIS

This study was undertaken in order to analyze and compare the mechanics of the single leg clear in field hockey between novice and skilled goalkeepers through cinematographic techniques. Velocity curves of the right shoulder, knee, ankle, and toe of a novice and of a skilled goalkeeper were computed and graphed. This analysis will be divided into four parts, so that each joint analyzed will be compared separately. The analysis of this skill begins after the left foot contacts the ground, as determined by viewing the side film, and ends as forward movement terminates in each joint studied as was determined by all three films. This analysis was made on only two subjects, one novice and one skilled goalkeeper.

Analysis of the Right Shoulder

The following information can be found on Figures 1a, 2a, and 4. At the beginning of the skill, as the clearing leg moves toward the ball, the forward movement of the skilled performer's shoulder increases, keeping the body weight over the stationary leg. The forward movement of the novice's shoulder decreases, keeping the body weight

slightly in back of the stationary leg. Both subjects' shoulder velocities increase through ball contact.

After ball contact, the forward movement of the skilled performer's shoulder increases, reaching a peak velocity of 102 inches/second .16 seconds after ball contact as the shoulder begins to rotate quickly toward the path of the cleared ball. Forward movement continues as the body weight is moved over the clearing foot, ending .60 seconds after ball contact.

After ball contact, the forward movement of the novice's shoulder increases sharply as balance is regained and decreases as the clearing leg is lifted into the air. Forward movement of the novice's shoulder again increases as the shoulder, rotating quickly toward the path of the cleared ball, reaches a peak velocity of 102 inches/second .37 seconds after ball contact. The clearing foot returns to the ground causing the body weight to move over the stationary leg. Forward movement of the novice's shoulder then decreases steadily, ending .75 seconds after ball contact.

Analysis of the Right Knee

The following information can be found on Figures 2b, 3a, and 4. As the clearing leg moves toward the ball, both the novice and skilled performers' knee flexes slightly. Forward movement of both subjects then decreases just before the knee begins to extend, and movement changes to a

diagonal line of direction. Diagonal movement increases as the knee of both subjects extends. The skilled performer's knee reaches a peak velocity of 188 inches/second .07 seconds before ball contact, and the novice's knee reaches a peak velocity of 222 inches/second .04 seconds before ball contact.

The knee velocity of both subjects decreases through ball contact but perhaps for different reasons. Knee velocity of the skilled performer decreases as the foot encounters ball resistance. The novice's knee velocity decreases partly as a result of encountered ball resistance, but also due to the fact that the clearing leg has to overcome gravity as it begins to lift off the ground.

After ball contact, movement diagonally sideward increases with both subjects as the knee continues to extend. Increased movement is due to increased momentum of the clearing leg after ball contact. The novice's leg moves diagonally upward while the skilled performer's leg moves diagonally sideward.

Forward movement increases in both subjects as the clearing foot moves toward the ground. The novice's knee velocity is greater at this point than the skilled performer's knee velocity, because the novice's knee has a further distance to descend and therefore gains momentum.

As the body weight of both subjects begins to move over the clearing foot, the knee begins to flex slightly.

As the clearing foot of both subjects comes in contact with the ground, forward movement decreases, ending .42 seconds after ball contact for the skilled subject and .58 seconds after ball contact for the novice.

Analysis of the Right Ankle

The following information can be found on Figures 1b, 2c, 3b, and 4. Ankle movement diagonally forward in an extended position increases in both subjects as the clearing foot moves toward the ball. Where the ankle of both subjects begins to flex, the skilled performer's ankle velocity increases as the ankle rotates quickly away from the ball in order to be in a "cocked" position. The novice's ankle velocity decreases slightly as the clearing foot pauses momentarily before moving toward the ball.

Both subjects' ankle velocities increase sharply before ball contact. The skilled performer's ankle rotates quickly toward the ball, flexing as it rotates, bringing the foot off the ground and reaching a peak velocity of 307 inches/second .04 seconds before ball contact. During this same time, the novice's ankle continues to move diagonally forward, gaining momentum as the knee extends and the ankle flexes, reaching a peak velocity of 307 inches/second .02 seconds after ball contact.

During ball contact, the skilled performer's ankle velocity decreases as the clearing foot meets ball resistance.

The novice's ankle velocity increases as the clearing foot "tops" the ball, thereby meeting little or no ball resistance.

After ball contact, both subjects' ankle velocities increase. The skilled performer's ankle picks up momentum and continues to rotate while moving slightly forward. The novice's ankle continues to flex as increased momentum from hip flexion continues to send the clearing foot diagonally forward into the air. At this point the novice's velocity decreases as maximum height of the clearing foot is gained, and the foot then pauses slightly before descending toward the ground.

Forward movement increases as the ankle of both subjects begins to extend, dropping the clearing foot toward the ground. The skilled performer's ankle continues to rotate until the clearing foot is on the ground. Before the novice's foot touches the ground, the ankle is rotated slightly inward. Forward movement in the ankle of both subjects gradually decreases, ending .15 seconds after ball contact for the skilled performer's ankle and .40 seconds after ball contact for the novice's ankle.

Analysis of the Right Toe

The following information can be found on Figures 1c, 2d, 3c, and 4. Movement diagonally forward of the toe of both subjects increases as the clearing foot moves toward the ball. Velocity for both subjects increases when the

ankle begins to flex. The skilled performer's toe rotates quickly away from the ball, in order to be in a "cocked" position. The novice's toe is carried diagonally upward.

Diagonal movement forward in the toe of both subjects decreases. Increased flexion of the skilled performer's ankle lifts the toe from the ground. The novice's toe velocity decreases as the toe pauses slightly before moving toward the ball.

Toe velocity for both subjects increases sharply before ball contact. In this instance the skilled performer's toe rotates quickly toward the ball, rising off the ground as it rotates, and reaching a peak velocity of 460 inches/second .04 seconds before ball contact. The novice's toe continues to move diagonally upward, reaching a peak velocity of 494 inches/second .02 seconds after ball contact.

During ball contact, the skilled performer's toe velocity decreases as the clearing foot meets ball resistance. The novice's toe velocity increases as the clearing foot "tops" the ball, thereby meeting with little or no ball resistance.

After ball contact, toe velocity decreases for both subjects. The skilled performer's toe is lifted in an arc from the ground, and the novice's toe reaches maximum height of the kick. Moving diagonally forward, the toe velocities of both subjects increase. The skilled performer's toe

rotates downward, and the novice's foot descends to the ground. Before the novice's foot touches the ground the toe is rotated slightly inward.

Forward movement decreases in the toe of both subjects as the clearing foot nears the ground, ending .15 seconds after ball contact for the skilled performer and .35 seconds after ball contact for the novice.

General Discussion

Reliability was derived by repeating the procedure used to obtain velocity between the plotted points. Points were again plotted on paper as the film was projected frame by frame, plotting only one joint for each of the three films. By measuring the distance and time between each point, velocity was computed. The velocities of the first plotting were then compared with the velocities of the second plotting yielding a perfect correlation.

When comparing velocity curves on both subjects, Figure 4 clearly shows that in all cases, the peak velocity of the novice is reached later than that of the skilled. The most important peak velocities occur in the ankle and toe of both subjects. The peak velocity of the skilled performer's ankle and toe occurs before ball contact, whereas the peak velocity of the novice's ankle and toe occurs after ball contact. The greater the velocity of the striking implement at the moment of contact, the greater the velocity of the struck ball. (13)

The skilled performer's joints studied move a greater distance before ball contact than do the novice's joints. The novice's joints move a greater distance after ball contact. The greater the distance over which momentum can be developed, the greater the momentum possible. (1) Therefore, the skilled subject builds up greater momentum before ball contact where the added momentum can be used toward the ball. The novice subject builds up greater momentum after ball contact.

The skilled subject takes a greater length of time for knee flexion before extending prior to ball contact than does the novice. This permits the leg to move forward with greater angular velocity because of the shortened radius. (2) Bending the leg adds force to the kick. (2)

The skilled performer's ankle is rotated away from the ball, or is "cocked" before rotating toward the ball. Therefore, the skilled performer's toe has a greater distance to travel before ball contact and therefore, the greater momentum is possible. The novice's ankle is not "cocked", but rather the whole leg is moved diagonally forward toward the ball.

The skilled performer's toe is rotated up off the ground just before ball contact, so that the ball can be struck clearly at its center of gravity. The novice's toe lifts off the ground too soon before ball contact, thereby "topping" the ball. The more nearly the object

being struck is contacted in line with its center of gravity, the greater the force transferred to the object in the desired direction. (1) A ball contacted above its center of gravity is hit more down into the ground than it is forward. (1)

The desired direction of the single leg clear is generally toward the sideline. The movement of the skilled performer's ankle and toe is directed much more toward the sideline at ball contact, whereas the movement of the novice's ankle and toe is directed more forward.

In all joints studied, the novice's movement requires a greater time for completion than does the skilled performer's movement. A goalkeeper must recover as quickly as possible from executing a clear, so that she is ready for another quick shot at the goal. The skilled subject is ready for another shot at the goal before the novice has even completed her initial clear.

The novice's knee and toe peak velocity is greater than that of the skilled performer. The novice seems to be aiming too much for power and very little for accuracy, while the skilled subject aims for a combination of both.

The skilled performer's body weight is kept more over the stationary leg at ball contact, whereas the novice's body weight is kept more to the rear of the stationary leg, thereby giving the skilled subject greater stability. Unless the body has good stability when it is

giving impetus to an object, much of the force is wasted. (13) Therefore, the skilled subject used more efficient movement, and much of the novice's movement is wasted.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was undertaken to determine some of the differences between novice and skilled goalkeepers in field hockey. Two subjects, one novice and one skilled goalkeeper, executed the singled leg clear. Velocity curves were computed from motion pictures taken during the performances. In the total analysis, the most important differences turned out to be the moment of peak velocity in the ankle and toe, ankle and toe rotation, point of contact with the ball, direction of the clear, and where the body weight is centered at ball contact.

Conclusions

After analyzing the front, side, and top films through the use of velocity curves, the following conclusions have been drawn:

1. Peak velocity of the ankle and toe should be reached before ball contact.
2. The body weight should be kept forward, over the stationary leg, during ball contact.
3. The ankle and toe should rotate away from the ball, or be in a "cocked" position, before rotating toward the ball.

4. The Clearing foot should rise slightly in order to contact the ball at its center of gravity.
5. In the single leg clear, the desired direction of the cleared ball is to the side; and therefore, the direction of movement of the clearing toe should be to the side and forward rather than completely forward.

Recommendations

After using cinematographic techniques to study the single leg clear in field hockey, the following recommendations have been drawn:

1. In teaching the single leg clear, the following suggestions will be helpful to coaches.
    a. The goalkeeper should bend forward slightly from the waist to keep the body weight over the stationary leg during ball contact.
    b. The ankle and toe should be "cocked" before rotating toward the ball.
    c. The clearing foot should lift slightly to meet the ball rather than slide along the ground, as was suggested by many authors covered in the review of literature.
    d. Sideward direction of the clear should be emphasized.

2. A more significant analysis could have been made by using more subjects.
3. A better analysis could have been made with improved cinematographic techniques.
4. A more complete analysis could have been made if the hip movements were analyzed along with the other joint movements.

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APPENDIX

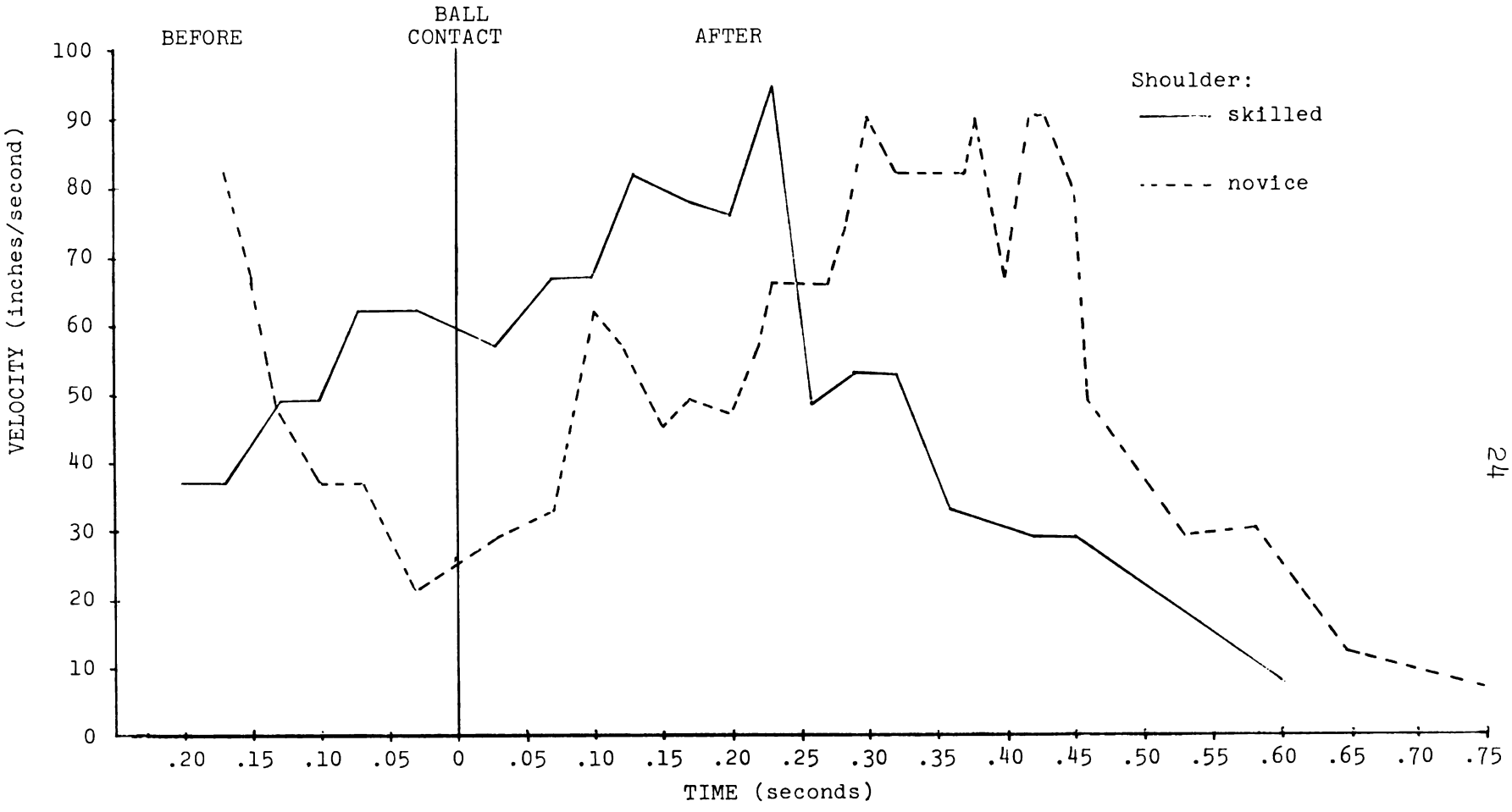

Figure 1a.--Top film, shoulder

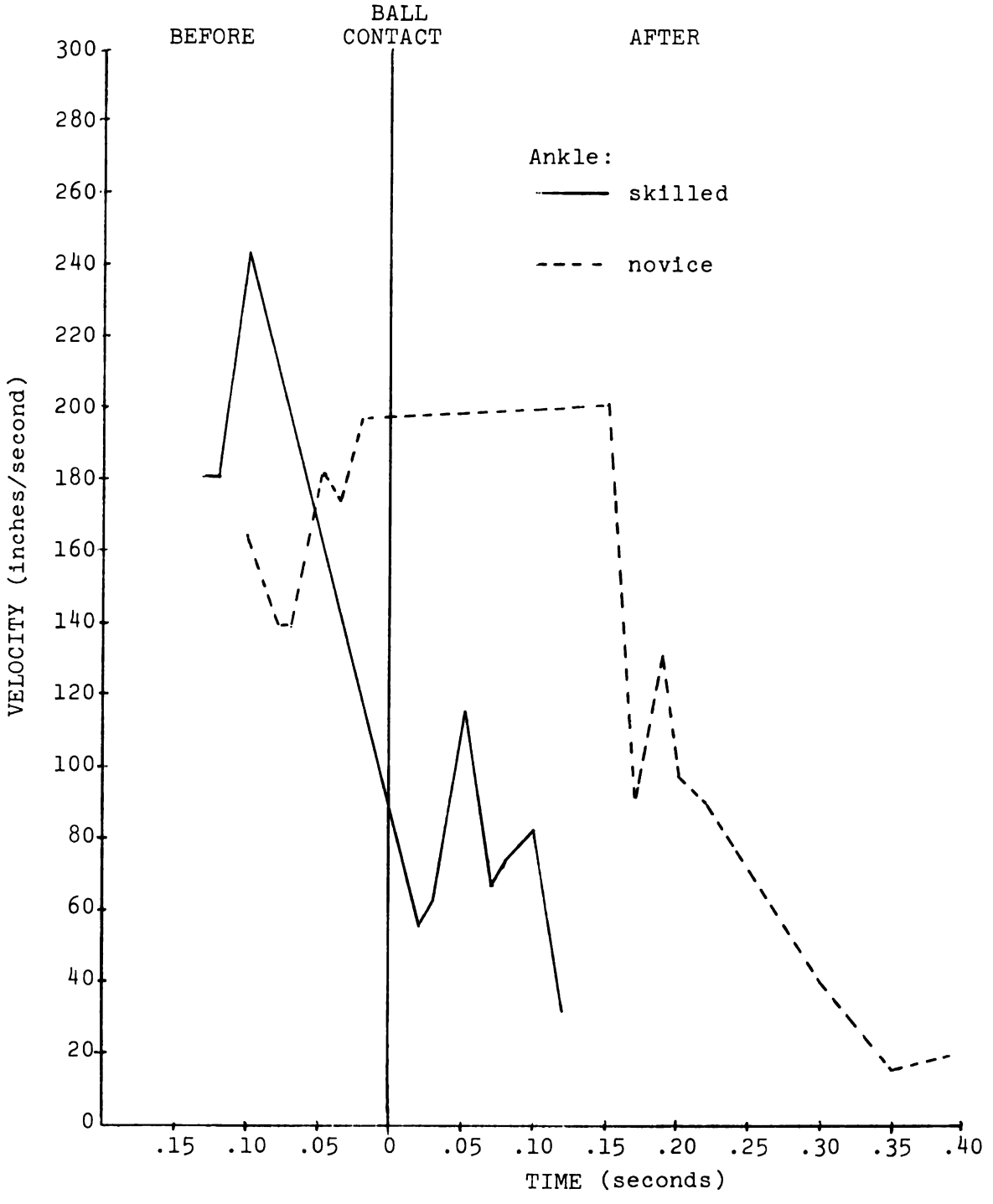

Figure 1b.--Top film, ankle

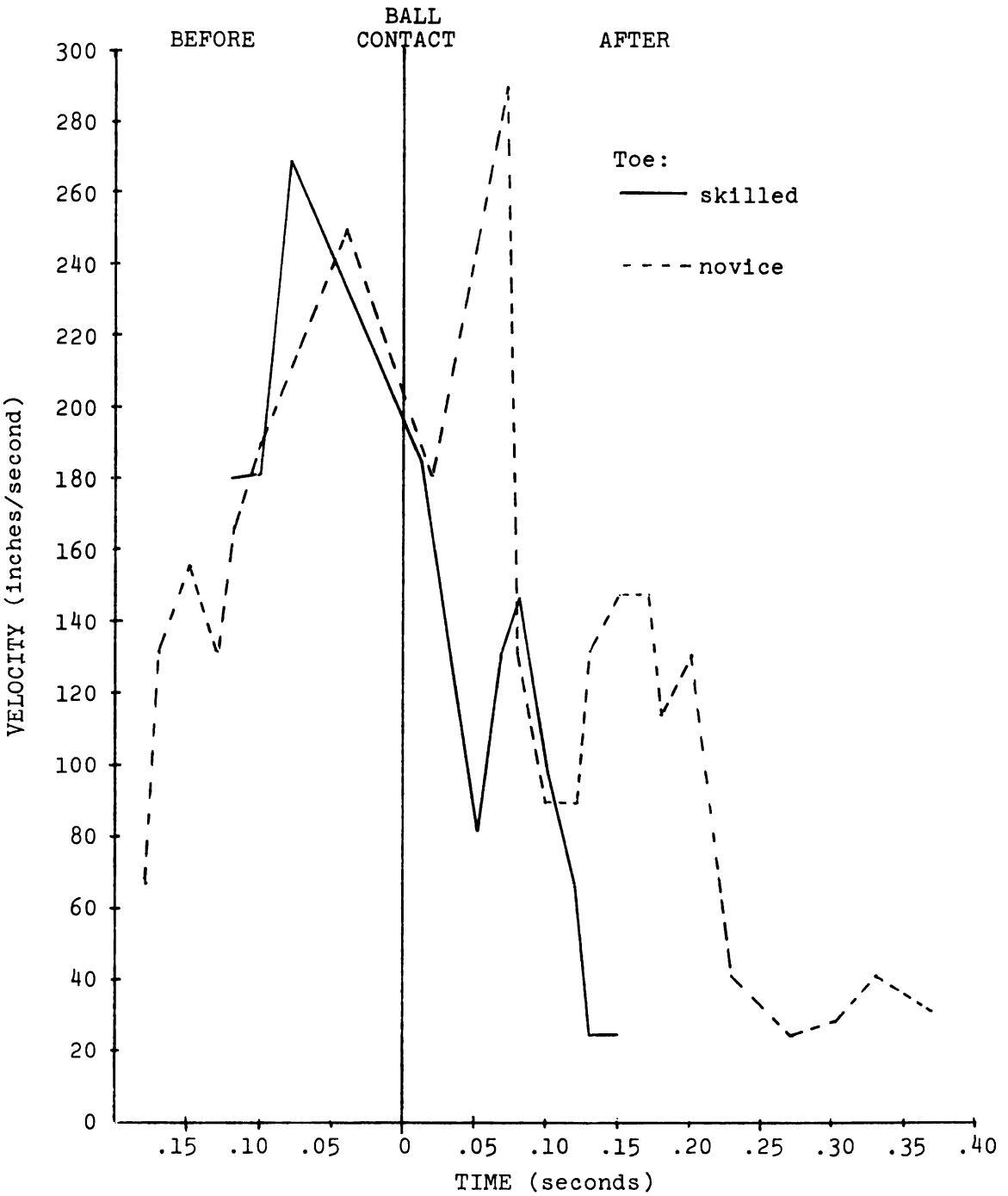

Figure 1c.--Top film, toe

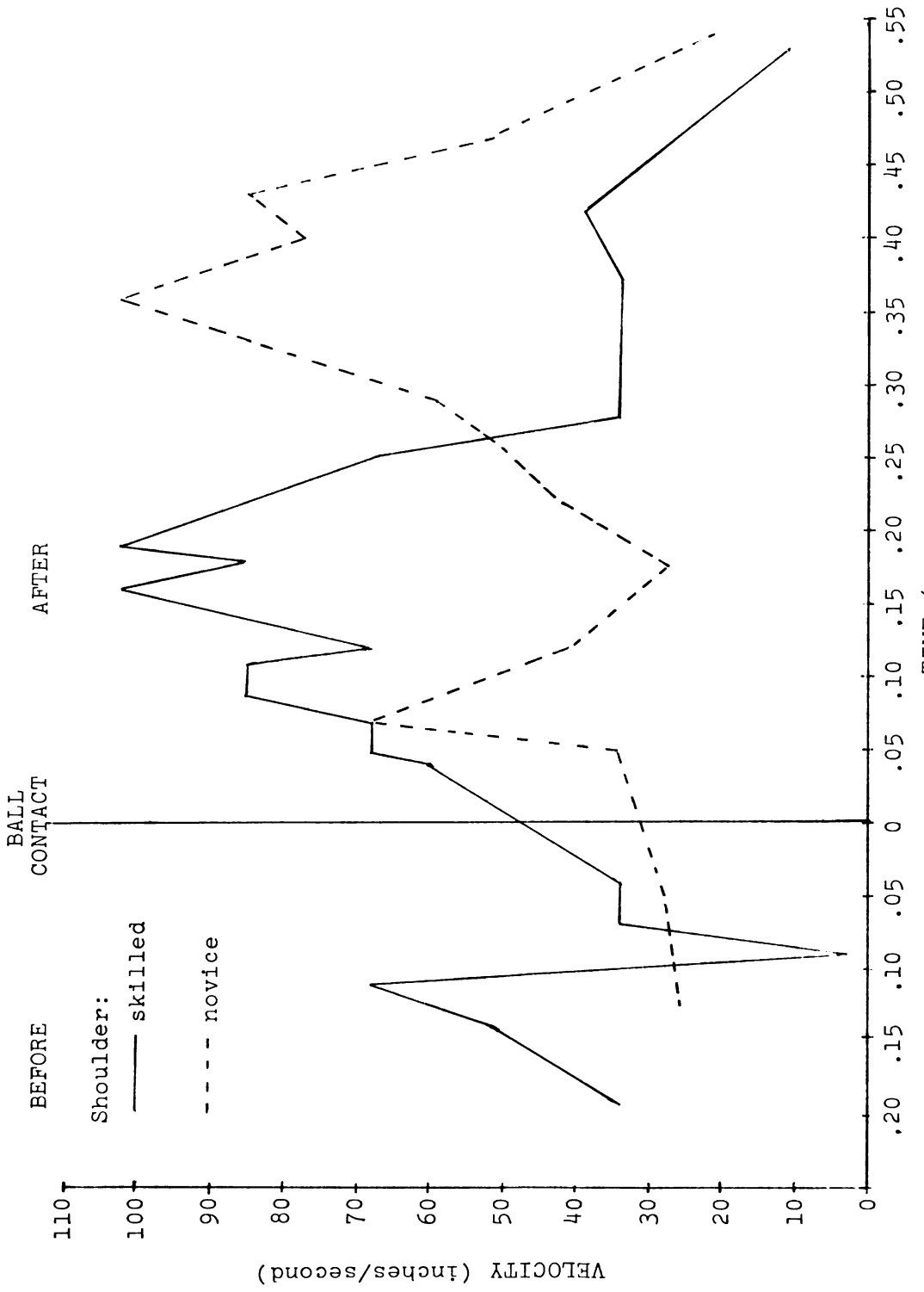

Figure 2a.--Front film, shoulder

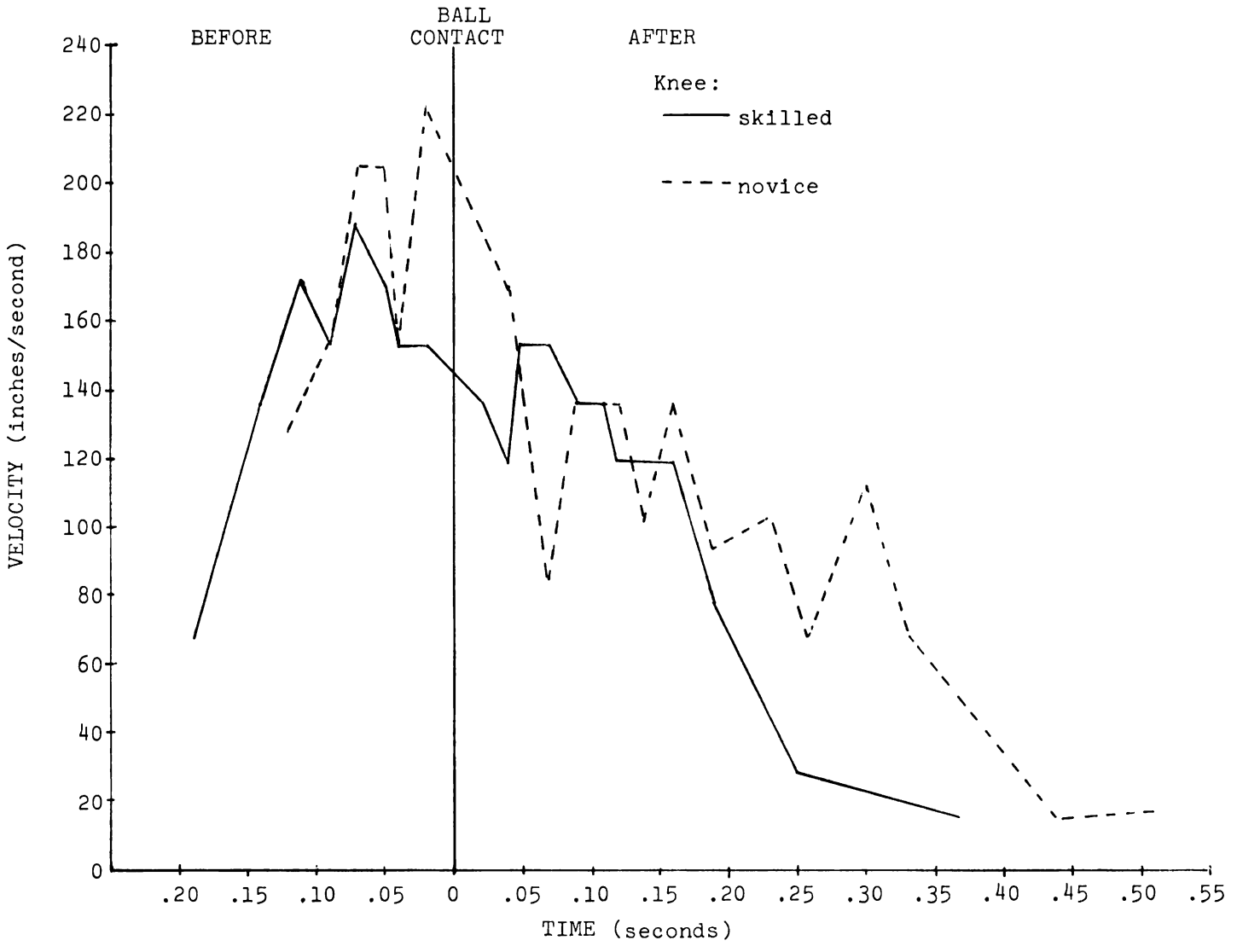

Figure 2b.--Front film, knee

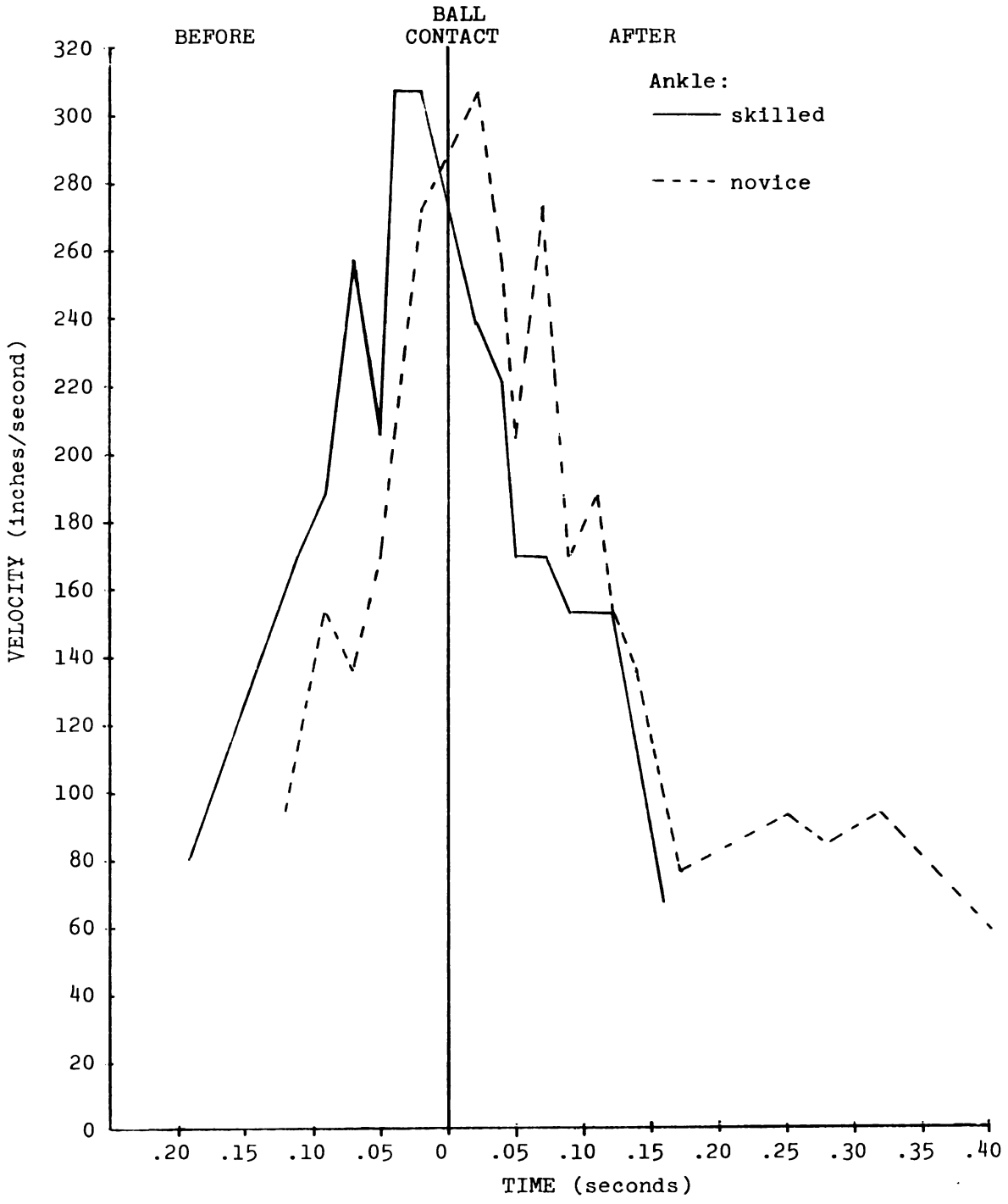

Figure 2c.--Front film, ankle

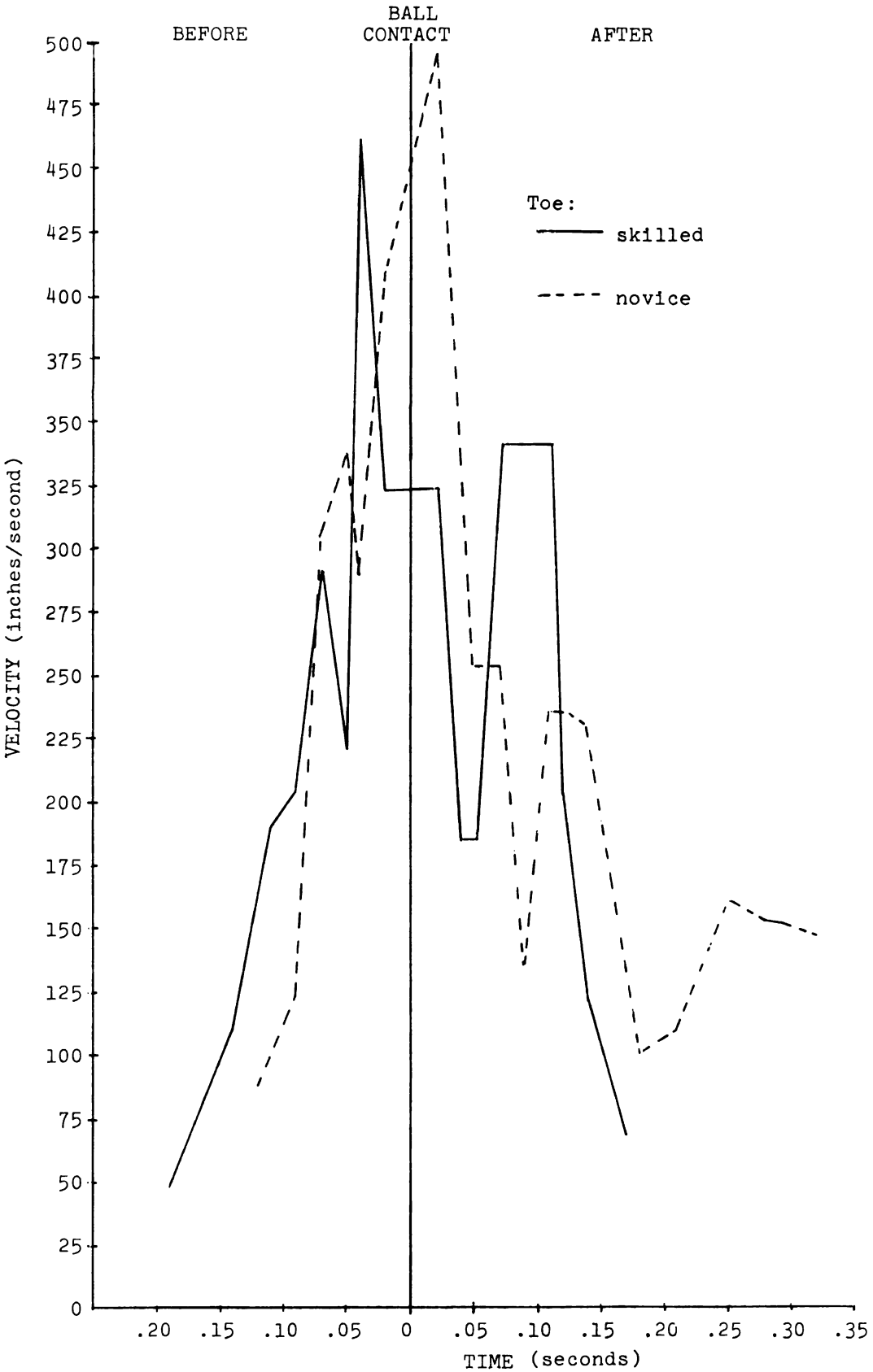

Figure 2d.--Front film, toe

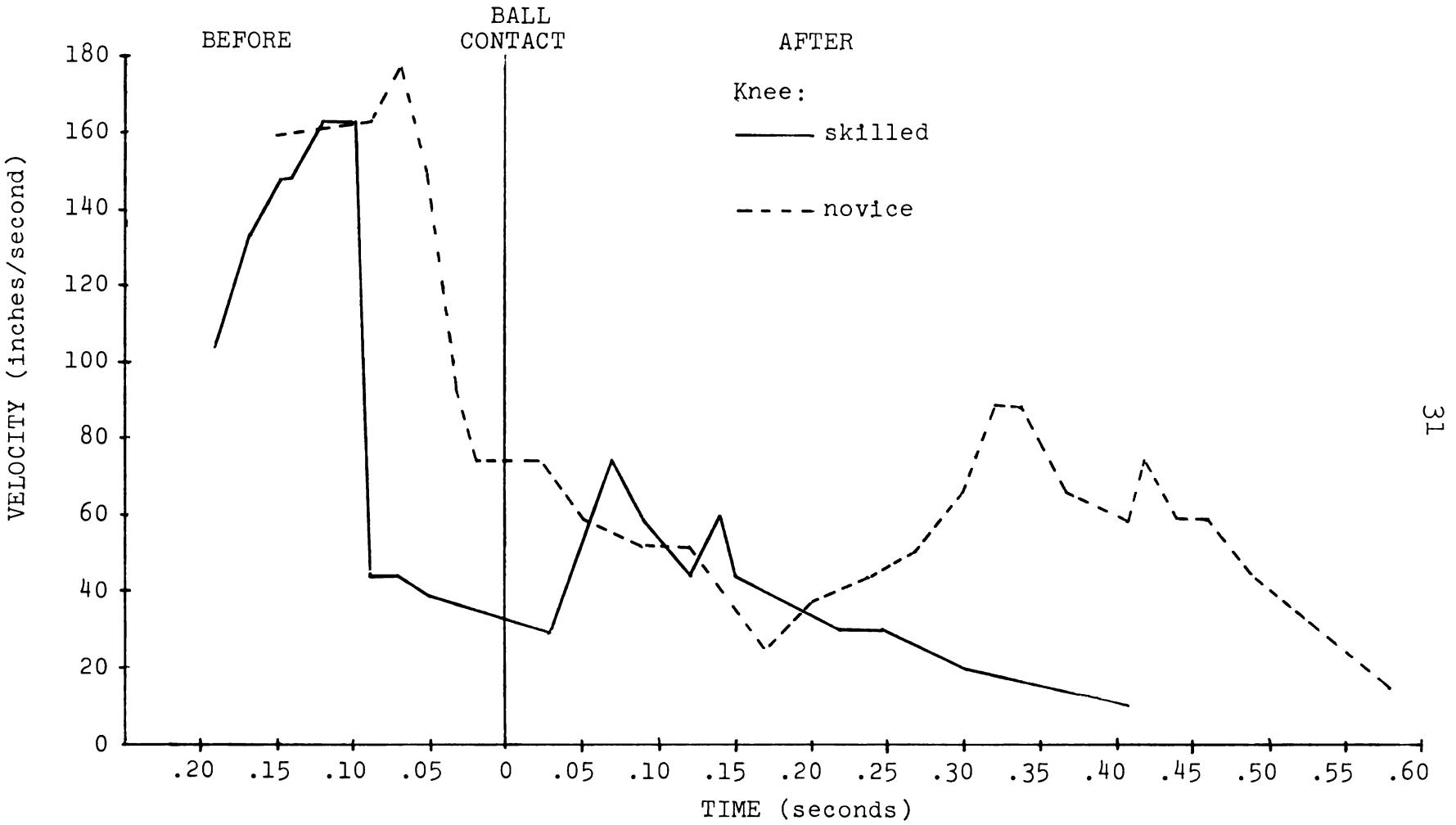

Figure 3a.--Side film, knee

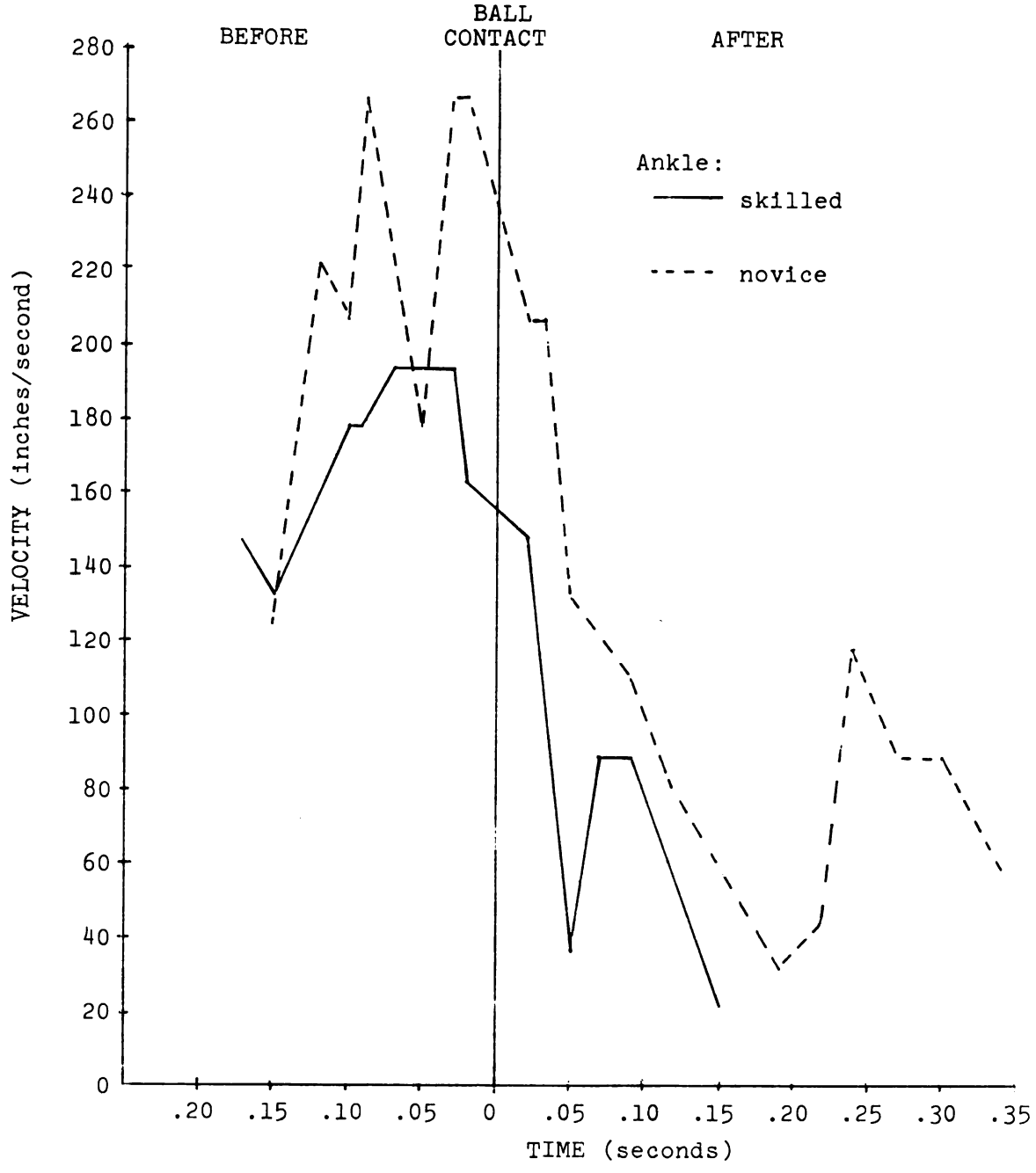

Figure 3b.--Side film, ankle

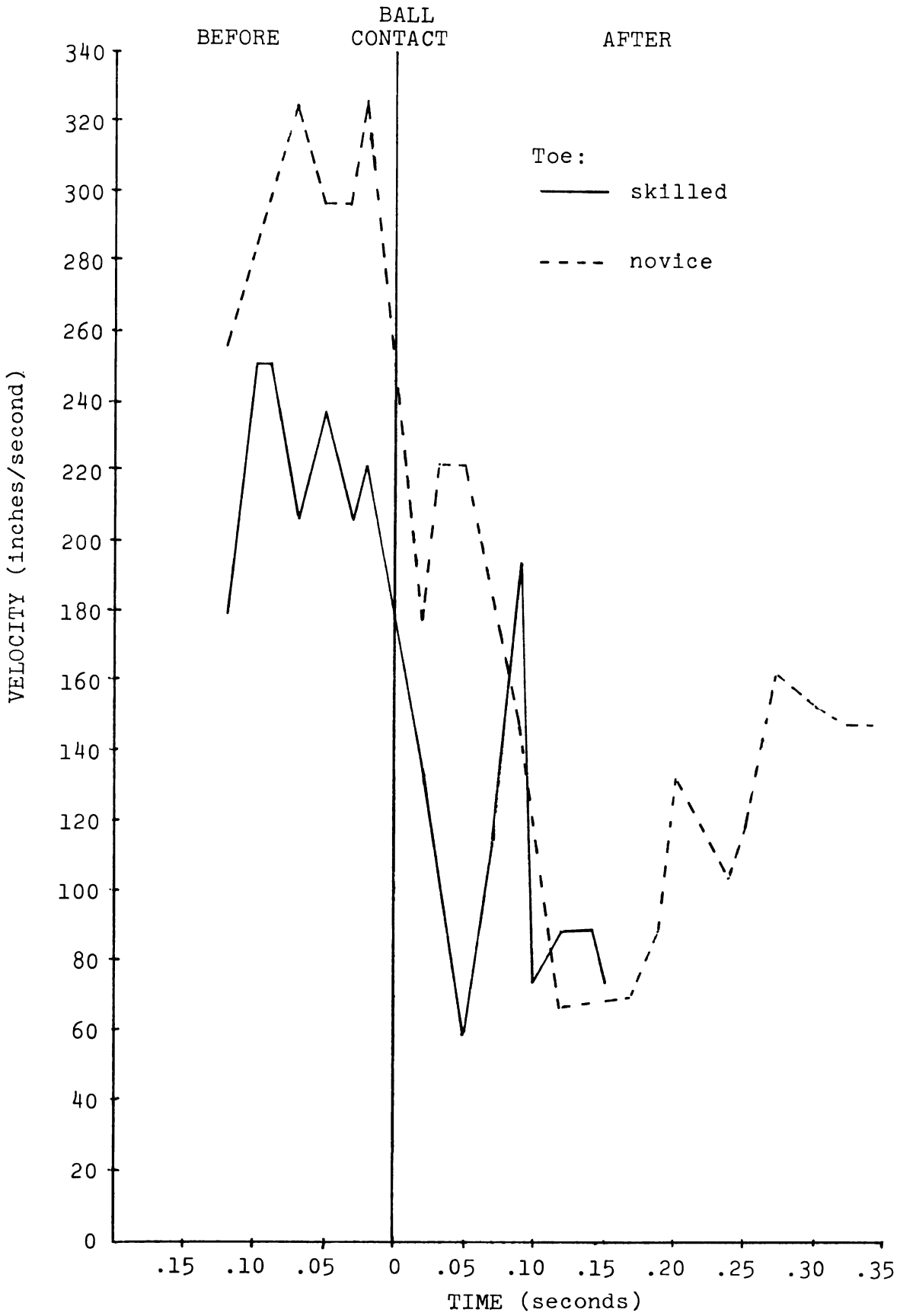

Figure 3c.--Side film, toe

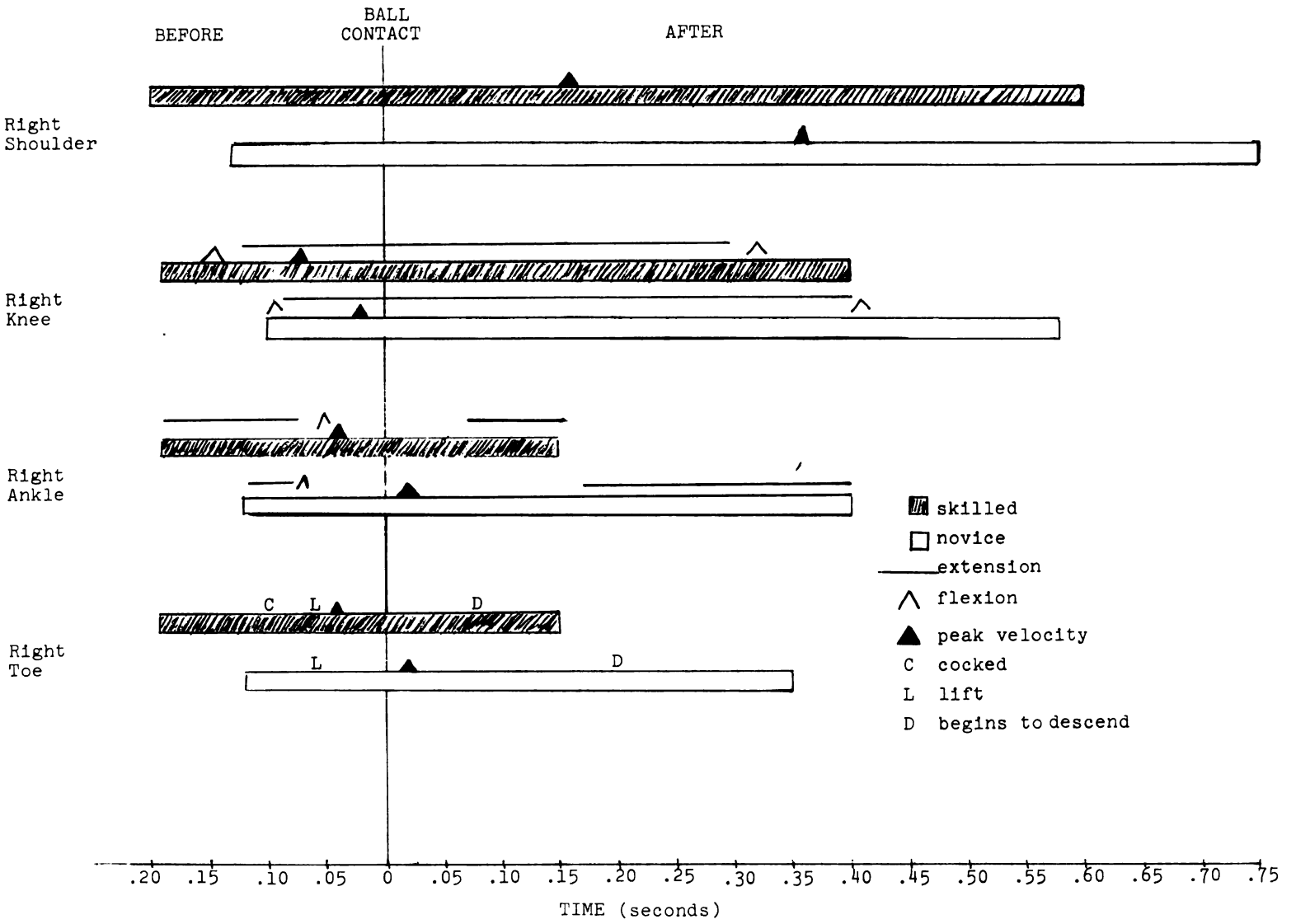

Figure 4.--Types of movement shown for the shoulder, knee, ankle, and toe.