12-1993

The Biomechanical Analysis of Two Types of Place Kicks: The Toe and Instep Kicks

KayLynn Albers
Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/masters_theses
Part of the Sports Medicine Commons, and the Sports Studies Commons

Recommended Citation
Albers, KayLynn, "The Biomechanical Analysis of Two Types of Place Kicks: The Toe and Instep Kicks" (1993). Master's Theses. 3310. https://scholarworks.wmich.edu/masters_theses/3310

This Masters Thesis-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Master's Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact maira.bundza@wmich.edu.
THE BIOMECHANICAL ANALYSIS OF TWO TYPES OF PLACE KICKS: THE TOE AND INSTEP KICKS

by

KayLynn Albers

A Thesis
Submitted to the
Faculty of the Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Health
Physical Education, and Recreation

Western Michigan University
Kalamazoo, Michigan
December 1993
THE BIOMECHANICAL ANALYSIS OF TWO TYPES OF PLACE KICKS: THE TOE AND INSTEP KICKS

KayLynn Albers, M.A.
Western Michigan University, 1993

This study described the biomechanical differences between two styles of the place kick; the toe kick and instep kick. The biomechanical variables included joint angles, velocities, and displacements. Five high school age subjects kicked five trials of the toe kick and five trials of the instep kick at both 20 and 35 yards. The place kicks were filmed with a high speed camera, digitized and analyzed with peak 4.2 computer software.

The findings for joint angles were consistent with those found in the literature. The velocity for the kicking foot and the ball were lower in this study than found in the literature. Subjects lateral and posterior displacements were greater than the displacements found in the literature. The greater displacement did not produce more power or velocity.

It was concluded that the subjects did not have the leg strength required to kick a 35 yard field goal. The toe style kick was found to be the most effective place kick at 20 yards resulting in a higher rate of success.
ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Dr. Mary Dawson for her advising and personal interest in my studies. Her expertise is what made this project possible. The guidance and support was much needed and appreciated.

I would also like to thank Dr. Deb Berkey and Dr. Roger Zabik for the time they spent as committee members. Their questions and attention to the study were greatly appreciated.

I would also like to thank all of the professors with whom I took classes with at Western Michigan University. My Graduate College experience was a positive one.

KayLynn Albers
TABLE OF CONTENTS

ACKNOWLEDGEMENTS ................................................................. ii
LIST OF TABLES ................................................................. vi

CHAPTER

I. INTRODUCTION ................................................................. 1
  Statement of the Problem ................................................. 2
  Statement of the Purpose ................................................. 2
  Need for the Study ......................................................... 3
  Delimitations ............................................................... 3
  Limitations ................................................................. 3
  Basic Assumptions ......................................................... 4
  Definitions of Terms ..................................................... 4

II. REVIEW OF LITERATURE .................................................. 6
  Cinematography ............................................................ 6
  Analysis of Kicking ....................................................... 9
    Stance ................................................................. 10
    Approach .............................................................. 10
    Contact ............................................................... 11
    Follow Through ...................................................... 12
    Biomechanical Factors ............................................. 13
    Related Literature ................................................ 13

III. METHODS ................................................................. 15
  Subjects ................................................................. 15
# Table of Contents—Continued

## CHAPTER

| Instrumentation                           | 16 |
| Filming Procedures                       | 17 |
| Collection of Data                        | 18 |
| Data Extraction                           | 18 |
| Data Analysis                             | 19 |

### IV. RESULTS AND DISCUSSION

| Results                                      | 21 |
| Angles                                      | 21 |
| Trunk                                       | 22 |
| Thigh                                       | 22 |
| Knee                                        | 26 |
| Velocity                                    | 28 |
| Displacement                                | 31 |
| Subject Position                            | 33 |
| Ball                                        | 33 |
| Approach Angle                              | 35 |

| Discussion                                  | 36 |
| Angles                                      | 36 |
| Trunk                                       | 36 |
| Thigh                                       | 38 |
| Right Knee                                  | 39 |
| Velocity                                    | 40 |
| Ball                                        | 40 |
### Table of Contents-Continued

**CHAPTER**

Subject Position .................................. 41

Approach Angle .................................. 43

V. SUMMARY, FINDINGS, CONCLUSIONS,  
AND RECOMMENDATIONS ............................ 44

Summary ........................................... 44

Findings .......................................... 45

Angles ............................................. 45

Velocity .......................................... 47

Displacement ...................................... 47

Conclusions ....................................... 48

Recommendations ................................. 49

**APPENDICES**

A. Assent Form ................................... 50

B. Consent Form ................................... 52

C. Human Subjects Institutional Review  
Board Approval .................................... 54

D. Filming Report .................................. 56

**BIBLIOGRAPHY** ................................. 58
LIST OF TABLES

1. Average Trunk Angle Over Five Trials at the Penultimate Step, Ball/Foot Contact, and Follow Through ............................................ 23

2. Average Thigh Angle Over Five Trials at the Penultimate Step, Ball/Foot Contact, and Follow Through ............................................. 25

3. Average Right Knee Angles Over Five Trials at the Penultimate Step, Ball/Foot Contact, and Follow Through ............................................. 27

4. Average Left Knee Angles Over Five Trials at the Penultimate Step, Ball/Foot Contact, and Follow Through ............................................. 29

5. Average Resultant Velocity of the Kicking Foot Over Five Trials ........................................................ 30

6. Average Resultant Velocity of the Football Over Five Trials ........................................................ 32

7. Average Horizontal Displacement of the Subject, Laterally and Posteriorly From the Ball Between Stance and Support Foot Plant ............................................. 34

8. Average Angle of Approach Over Five Trials From Stance to Support Foot Plant ............................................. 37
CHAPTER I

INTRODUCTION

Football is one of America's greatest spectator sports. The art of kicking has evolved into a major aspect of game strategy, which includes poor field position for the opponent. Poor field position will restrict the opponent's offense. Lou Groza, a professional football player and kicking specialist explained:

If a team doesn't have a place kicking threat, the opponent can spread the defense on the goal line and make it much more difficult to run or pass for the two-point conversion; with the kicking threat you are sure of one-point, and the two points will be easier since the opposition will have to put pressure on your kicker. Also, a three point field goal will come in handy in erasing a two-point conversion edge (Doust, 1959, p.123).

The importance of the field goal or point after touchdown can easily be seen during any weekend during the football season. Many high school, college, and professional games are often won by three points or less. The field goal in American football has become a powerful weapon. There have been many accurate field goal kickers within the last few years. One reason for the increase in kicker's consistent scoring performance is the initiation of the soccer style or instep style place kick in the game of football. The soccer style or instep style place kick
was first introduced in the United States in the early 1960's.

Presently, in the National Football League, the majority of place kickers use the instep kick. Prior to the 1960's however, there was great success with the conventional or toe style kick. Because of the proven success of both styles of place kicking, there is merit in investigating the biomechanical factors involved in each style of kick.

Statement of the Problem

This study was designed to biomechanically analyze the football and the kicker during the performance of two types of place kicking: the toe kick and the instep kick. Specifically, the study investigated kinematic variables of the lower extremities and the trunk.

Statement of the Purpose

The purpose of the study was to extend the knowledge base regarding two styles of the football place kick: instep and toe kicks. This study will lead to a better understanding of the complex body movements needed in each style of the place kick for the purpose of teaching and coaching.
Need for the Study

Few biomechanical studies have been conducted investigating the differences between the toe kick and the instep kick. The study should provide information to benefit football coaches who coach younger teams, age 15 to 18 years. The results of this study should help coaches decide which style of the place kick will be best suited for the athlete kicking the football.

Delimitations

The study was delimited to two styles of football place kicking: (1) instep style and (2) toe style. Five male high school athletes from the Holland/Zeeland area in Michigan were the subjects in this study. Each subject had previous knowledge of how to perform each style of place kick.

Limitations

The results of this study were limited by each subjects' consistent performance with each style of kicking. The subjects were not randomly selected. The results of this study were limited to high school level performance, and may not represent other kickers.
Basic Assumptions

There are two basic assumptions in this study: Each subject put forth maximum effort with each kick and fatigue was not a factor.

Definition of Terms

The following terms are used throughout the paper. All terms refer to football place kicks.

1. Acceleration - The rate at which the velocity changes with respect to time (Hay, 1985).

2. Air resistance - Alteration of the path of motion of an object due to wind conditions and gravity (Hay, 1985).

3. Approach - To move close to or towards the ball. In place kicking usually one and one half to two steps are taken (Leighty, 1968).

4. Contact - The foot hits the ball with the toes up and the heel down (Leighty, 1968).

5. Displacement - The distance the ball traveled after contact towards the kicking teams goal line (Hay, 1985).

6. Instep kick - When the ball is kicked with the inside or medial aspect of the foot (Hewlett & Bennett, 1969).

7. Place kick - The football is placed on a tee and
kicked down field towards the kicking teams goal line (Leighty, 1968).

8. Power - The rate at which work is performed (Hay, 1985).

9. Toe kick - When the ball is kicked with the toes or square part of a kicking shoe (Blaettler, 1967).

10. Velocity - The change in position with respect to time (Hay, 1985).
There are four different kicks used in football today. Three of these require the use of a kicking tee. They include the kickoff, field goal attempt, and the point after touchdown (PAT). The fourth kick is the punt which is dropped from the waist and then kicked after it has dropped for some distance. In each type of kick, the distance that the ball travels or success depends on the speed, height, and the angle at which the ball leaves the kicker's foot (Hay, 1985). Air resistance will be a factor in the success of the kick.

Few studies have been completed on the biomechanical analysis of the place kick in football. This chapter will review the related studies as well as display the proper techniques of the toe and instep style place kicks. The chapter is organized into four categories: cinematography, the analysis of kicking, biomechanical factors, and related literature.

Cinematography

The rapid speed of a football place kick requires the use of cinematography to actually see what happens. Seven
of nine studies found used a two-dimensional (2-D) cinematographic setup: Alexander and Holt (1974), Davies (1969), Blaetter (1967), Rexroad (1965), Cunningham and Dowell (1976), Macmillan (1976). Roberts and Metcalfe (1968) and Stanton (1974) used a 3-D camera setup for their studies. Miller and Nelson (1973) explained twelve factors needed in 2-D filming to obtain accurate data. These factors are explained below.

1. The event being filmed should be at a right angle to the camera's view. Only the movement in the plane of the film will be accurate. Perspective error will be high in other planes.

2. The camera distance from the action should be as great as possible to minimize the effect of perspective error. A telephoto lens should be used to enlarge the size of the image to be analyzed.

3. A stationary camera position is required. The camera should be able to encompass all action while leveled and secured to a tripod. Panning is not recommended because it complicates the film analysis, due to the additional reference measures required.

4. The background should be plain and contrast the subject or action being filmed. To orient the film during the analysis, horizontal and vertical references should be included if none exist in the natural background.

5. The subject should be well informed of the pro-
ject, and know what is expected of him. The researcher should provide a "normal" setting for the filming to take place.

6. To aid in the location of joint centers and segmental endpoints during the digitizing process, the subject should wear as few clothes as possible and all clothes worn should be form fitting. Contrasting markings placed on the joint centers and sports implements used in the performance can facilitate the digitizing process provided the marks do not move as a result of the performance.

7. It may be necessary to use artificial lighting to get enough light to expose the film.

8. For rapidly moving body parts, a high frame rate will avoid blurring.

9. The camera should be started prior to the action to allow sufficient time for the camera to accelerate to the desired frame rate.

10. To calibrate the speed of the camera, a light emitting diode should be used.

11. It is important to film an object of known length, such as a meter stick, to provide a scale factor.

12. Conditions, distances, and other important details of the filming should be recorded on a form. The literature reveals that most biomechanical studies used motor-driven 16mm cameras (Dainty & Norman, 1987). A motor-driven camera insures the researcher a more accurate
time interval between frames than the spring driven cameras. Macmillan (1975, 1976) used motor-driven cameras for filming a football kick. Stanton (1974) used two motor-driven cameras and one spring-driven camera for his research on a football kick. Other literature found did not stipulate the type of power used for the cameras.

Each study reviewed used a high quality lens to reduce lens distortion of the image. A zoom lens was used in each study to allow for a maximum image size. The film speed varied in each of the studies examined. Alexander and Holt (1974) used 150 fps for the side view and 60 fps for the front view. In Roberts and Metcalfe's (1968) research, 46 fps film speed was used for overhead, both sides, and front views. Cunningham and Dowell (1976) conducted a pilot study to determine film speed. The study concluded that 200 fps was adequate for the research project. A film speed of 400 fps was used in both of Macmillan's studies (1975, 1976). Stanton (1974) used 64 fps from the front, 150 fps from the side and top views. The distances that the cameras were from the subjects varied from 35 ft to 90 ft. The camera shutter speed varied from 1/400 to 1/1200 seconds.

Analysis of Kicking

The place kick consists of four phases or parts: (1) the initial stance, (2) the approach, (3) contact, and (4)
follow through (Hay, 1985).

**Stance**

The stance in place kicking is the standing position taken prior to movement towards the ball. Leighty (1968) suggested that in the stance phase the kicker should include three normal walking strides behind the spot of ball placement. Most kickers have some predetermined distance that is always used in the stance phase. Hay (1985) stated that, in general, the distance for the initial stance is approximately two meters. Doust (1959), Leighty (1968), and Hay (1985) agreed that in a right footed kicker, the right foot should be slightly ahead of the left foot. The knees are slightly bent, the trunk is erect or slightly inclined forward, arms should be hanging comfortably at the side, and the eyes are focused on the spot where the foot will make contact with the ball (Hay, 1985; Leighty, 1968; & Doust, 1959).

**Approach**

The last two steps in the approach of the toe style place kick is started by a short normal step of the right foot. The left foot takes a much larger than normal step called the penultimate step. This step positions the left foot for support while providing the greatest range of motion for the right foot to kick through the ball. There
is much controversy as to where the non-kicking foot should be placed. Hay (1985) suggested 5 to 10 cm to the left of an imaginary line drawn from the goal to the kicking tee and about 15 cm behind the ball. Leighty (1968) suggested 6 to 8 inches behind the ball. Stanton (1974) discussed a study that used college men to determine the average distance the non-kicking foot is placed behind the ball. The distance ranged from 10.4 to 11.1 inches.

The soccer style or instep style approach is taken 1 to 2 normal steps to the left of an imaginary line drawn from the center of the goal post to the ball. The kicker then moves in an arc through two approach steps toward the ball.

Manzi (1967) compared the soccer style and the toe or straight style approach in terms of the distance and accuracy of the place kick. Manzi (1967) concluded that: (a) the soccer style approach leads to better accuracy from 20, 26, and 32 yds; and (b) no difference was shown to exist between kicking styles with respect to distance of ball travel in two step approaches.

Contact

Hay (1985) explained the lower body position prior to foot contact with the football:

The right knee is bent at or near a 90° angle and the right foot at hip height and well behind the line of the body...the right hip flexor contract forcefully to
swing the thigh forward and downward about a transverse axis (p. 260).

On contact, the foot and ankle should be rigid in both the instep soccer style (Stanton, 1974), and the toe kick (Blaetter, 1967). The ball should be contacted about 5 to 5.5 inches from the bottom and be tilted toward the kicker (Blaetter, 1967 & Marshall, 1958). The final outcome of the kick is determined by the position of the kicker prior to contact. Roberts and Metcalfe (1968) indicated that the time the foot is in contact with the ball is .015s. Hay (1985) explained five points that Roberts and Metcalfe illustrated for body positions at the instant of contact.

a) The foot is moving in an upward and forward direction at the instant contact is made with the ball, b) The knee is slightly flexed as the foot strikes the ball and the last few degrees of extension take place while the foot is in contact with the ball, c) The right hip is flexed to approximately 140° as contact is made and throughout the period of contact, indicating that the angular motion of the thigh has been reduced to zero, d) The head is forward and the back is somewhat rounded to allow the eyes to be focused on the ball, e) The arms (the left forward and the right to the side and slightly backward) act to "balance the action of the legs (Hay, 1985, p. 261)."

Follow Through

The follow through in place kicking helps protect the kicker from injury (Hay, 1985). The head should remain forward and down throughout the entire kick including the follow through (Blaetter, 1967). By keeping the head forward and down, the momentum of the body will carry throughout the follow through of the place kick and not interfere
with the projection of the ball.

Biomechanical Factors

Roberts and Metcalfe (1968) completed a mechanical analysis of a kick and found that knee extension does not start until the thigh is past the vertical which contributes to the speed at and through contact.

Stanton (1974) stated that the variables producing maximum ball velocity included rigidity of the kicking foot at contact, and kicking foot velocity. He found that each body segment that accelerated and decelerated during the kick contributed to the maximum velocity of the kicking foot prior to contact.

Davies (1969) had similar views as Stanton (1974). Each body segments forces are summed to apply a force to the ball. Davies cinematographically analyzed the toe kick and soccer style kick. He found that the soccer style kick had more potential for greater force because the kicking foot rotates and caused a greater ball-foot surface contact.

Related Literature

Eldridge (1971) compared the conventional toe kick to the rugby toe kick for accuracy and distance. Eldridge used experienced and inexperienced players. He did not find any difference between kicks or types of kicks in
distance or field goal accuracy.

Adel (1979) investigated the differences in distance and accuracy with the toe kick and instep kick. The results indicated that there were no significant differences in distance or accuracy between the styles.

Each author reviewed, suggested that research continue regarding the differences between the toe kick and instep kick. Davies (1969) and Eldridge (1971) suggested that more analytical studies should be conducted and include velocity of body segments summed in relation to the forces produced to kick the ball.
CHAPTER III

METHODS

This research study was designed to biomechanically analyze the complex body movements involved in two styles of the football place kick. The two styles studied were the toe kick and the instep kick. The purpose of the study was to increase knowledge regarding the biomechanics of each style of football place kicking. This chapter will explain the following in detail: (a) subjects, (b) instrumentation, (c) filming procedures, (d) data collection, (e) data extraction, and (f) data analysis.

Subjects

Five male subjects ranging in age from 15 to 18 years were invited to participate in this study. The subjects had previous varsity level football place kicking experience. Subjects were from the Holland / Zeeland, Michigan area and represented the Holland / Zeeland high school varsity football place kicking population. Each subject had prior experience performing the toe and instep styles of the place kick. Each subject signed an assent form and their parent signed a consent form (Appendix A & B). Appendix C contains the letter of approval from the Human
Subjects Review Board. The subjects in this study did not have neurological or orthopedic problems known to the researcher. All subjects had experience kicking both styles of the place kick prior to the study.

Instrumentation

Two Photo-sonic 1-PL 16mm cameras were used simultaneously to film subjects motion in the sagittal plane from the right side and in the frontal plane from the anterior side. The cameras were set 134 feet to the right and 103 feet to the left of the subjects' motion. The cameras were perpendicular to the sagittal and frontal planes. Camera calibration was monitored by a light emitting diode (LED) set at 100 pps. Each camera used video news film, ASA 400. Camera speed was set at 100 fps. The command "GO" was used to start the cameras approximately two seconds before the kicker initiated his approach to ensure the cameras had reached their maximum operating speed. A filming report (Appendix D) was used to indicate the camera specifications used by each camera.

The Vanguard Motion Analyzer projector was used to view the film after it was developed. A Neumonic 1224 digitizer was used to read the cartesian coordinates of selected points from the film to create a data file. The digitizer was interfaced to a Zenith 386/20 computer. The computer software used was the Peak Performance Measurement
System Software Version 4.2 (Peak Performance Technologies, INC., 1990). The program created and calculated a data file, stick figures, joint angles, angular kinematics, and linear kinematics.

Filming Procedures

The study took place at the Zeeland High School Stadium in Zeeland, Michigan. A goal post was used for the kicker's perspective. The yard lines were marked every five yards. The ball was placed exactly in line with the middle of the goal post for each kick. Each camera was placed perpendicular to the plane of motion filmed.

Each subject wore light colored shorts, ankle socks, and shoes. Small colored adhesive tape marks were attached to each subject at the following anatomical locations to aid in the location of the joint centers for the biomechanical analysis: (a) the lobe of the right and left ears, (b) Xiphoid process, (c) lateral aspect of each elbow, (e) styloid process of each ulna, (f) lateral and medial condyles of each tibia, (g) medial malleolus of right and left tibias, (h) lateral malleolus of each fibula, (i) tip of each shoe. The football was also marked with a thin solid line of tape down one side and a broken line down the other side to aid in analysis of its trajectory.

In a random order, each subject performed the following trials: (a) five toe kicks from 20 yards, (b) five
instep kicks from 20 yards, (c) five toe kicks from 35 yards, and (d) five instep kicks from 35 yards.

Collection of Data

The study took place at the Zeeland High School Stadium on October 3, 1992. The subjects randomly completed five attempts with each style of the place kick at 20 yards (the distance of the extra-point place kick) and five attempts with each style at 35 yards. The success of each kick was recorded as well as the immediate reaction of the kicker. A kick was determined to be successful if the ball passed through the goal uprights. Each subject was assigned a letter and will be referred to as Subject A through Subject E.

A meter stick was filmed in the place of action by each camera prior to the first kick at each distance, 20 and 35 yards. This served as a scale factor for film measurements.

Data Extraction

The film was digitized one frame at a time. The computer program took each point that was digitized and formed lines with respective points to create stick figures. The angles were then taken from the stick figures at each frame. (The joint angles are defined in the following paragraph). There were three event frames: (1) penulti-
mate step foot plant, (2) ball-foot contact, and (3) follow through.

The desired body segment angles were calculated by the Peak Performance Motion Measurement System 4.2 software (Peak Performance Technologies, INC., 1990). The segment angles were formed by the lines connecting the anatomical landmarks. The right and left ankle angles were formed by connecting the lines between the tip of the shoe to the midpoint of the lateral malleolus, and the midpoint of the lateral malleolus to the midpoint of the lateral tibial condyle. The right and left knee angles were measured by lines formed at the midpoint of the lateral malleous to the midpoint of the lateral tivial condyle to the midpoint of the greater trochanter. The right and left thigh angles were formed by the midpoint of the lateral condyle of the tibia to the midpoint of the greater trochanter with a line drawn perpendicular to the ground. The trunk angle was measured by a line formed at the midpoint of the crotch and the midpoint of the xiphoid process with a line drawn perpendicular to the ground.

Data Analysis

The independent variables included were style of kick, toe and instep, and distance, 20 and 35 yards. The dependent variables included the trunk lean and the dependent variables were the resultant velocity of the kicking foot,
location of the support foot in relation to the body, and resultant velocity of the ball after contact. Descriptive statistics were applied to the data.
CHAPTER IV

RESULTS AND DISCUSSION

Due to an injury to one of the subjects before filming the project, only four subjects participated in the study. The mean age for these subjects was 16.75 years, standard deviation was 0.96 year. There were three categories of measurements taken and compared. They included joint angles, body segment velocities and ball velocities, and displacement.

Results

Angles

Angles were measured at three event frames (critical points during the execution of the motion). The event frames were named penultimate step foot plant, ball/foot contact, and follow through. The penultimate step foot plant occurred when the non-kicking foot was planted next to the ball for support. Ball/foot contact occurred when the kicking foot came into contact with the ball. The follow through was measured when the kicking foot reached the highest vertical point prior to returning to the ground. Joint angles were measured at these event frames
during the motion of each kick.

**Trunk**

The trunk angle was measured with a vertical line and the line formed between the sternum and the crotch. Table 1 shows each subjects' degree of trunk lean for the toe kick and the instep kick during the event frames at 20 and 35 yards. Trunk angles in Table 1 can be compared within and between subjects by type of kick as well as yard placement.

There is little difference between the penultimate step average angles and contact average angles between kicks and distances. At contact the mean trunk angle at 20 yards for the four subjects using the toe kick was 266.1°. The standard deviation was 5.8. The mean trunk angle for the instep kick at 20 yards during the contact phase was 266.9° and the standard deviation was 8.1. At 35 yards for the toe kick, the mean trunk lean was 274.2° with a standard deviation 5.9. The mean trunk lean at 35 yards for the instep kick was 266.1° and the standard deviation was 5.2. Between the contact phase and the follow through phase, the trunk angles increased an average of 8.45°.

**Thigh**

The thigh angle was formed by a line drawn from the hip to the knee with a line drawn horizontally. Each sub
## Table 1

### Average Trunk Angles Over Five Trials at the Penultimate Step, Ball/Foot Contact, and the Follow Through

<table>
<thead>
<tr>
<th>Subjects</th>
<th>20 yards Events</th>
<th>35 yards Events</th>
<th>20 yards Events</th>
<th>35 yards Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>272.8 274.6 286.1 280.8 282.9 275.9 280.4 291.3 267.3 263.8 265.2</td>
<td>264.0 262.0 271.1 268.7 268.0 276.6 266.9 263.1 266.8 269.6 265.1 266.0</td>
<td>260.0 257.2 265.6 266.0 266.8 282.3 266.3 260.2 264.9 268.4 265.1 265.1</td>
<td>270.1 270.5 282.1 277.2 276.9 284.4 267.3 263.8 265.2 270.1 270.5 282.1</td>
</tr>
<tr>
<td>B</td>
<td>264.0 262.0 271.1 268.7 268.0 276.6 266.9 263.1 266.8 269.6 265.1 266.0</td>
<td>260.0 257.2 265.6 266.0 266.8 282.3 266.3 260.2 264.9 268.4 265.1 265.1</td>
<td>260.0 257.2 265.6 266.0 266.8 282.3 266.3 260.2 264.9 268.4 265.1 265.1</td>
<td>270.1 270.5 282.1 277.2 276.9 284.4 267.3 263.8 265.2 270.1 270.5 282.1</td>
</tr>
<tr>
<td>C</td>
<td>260.0 257.2 265.6 266.0 266.8 282.3 266.3 260.2 264.9 268.4 265.1 265.1</td>
<td>260.0 257.2 265.6 266.0 266.8 282.3 266.3 260.2 264.9 268.4 265.1 265.1</td>
<td>260.0 257.2 265.6 266.0 266.8 282.3 266.3 260.2 264.9 268.4 265.1 265.1</td>
<td>270.1 270.5 282.1 277.2 276.9 284.4 267.3 263.8 265.2 270.1 270.5 282.1</td>
</tr>
<tr>
<td>D</td>
<td>270.1 270.5 282.1 277.2 276.9 284.4 267.3 263.8 265.2 270.1 270.5 282.1</td>
<td>270.1 270.5 282.1 277.2 276.9 284.4 267.3 263.8 265.2 270.1 270.5 282.1</td>
<td>270.1 270.5 282.1 277.2 276.9 284.4 267.3 263.8 265.2 270.1 270.5 282.1</td>
<td>270.1 270.5 282.1 277.2 276.9 284.4 267.3 263.8 265.2 270.1 270.5 282.1</td>
</tr>
</tbody>
</table>

| X        | 266.7 266.1 276.2 273.2 274.2 285.7 269.1 266.9 272.1 268.9 266.1 269.6 | 266.7 266.1 276.2 273.2 274.2 285.7 269.1 266.9 272.1 268.9 266.1 269.6 | 266.7 266.1 276.2 273.2 274.2 285.7 269.1 266.9 272.1 268.9 266.1 269.6 | 266.7 266.1 276.2 273.2 274.2 285.7 269.1 266.9 272.1 268.9 266.1 269.6 |
| SD       | 5.8 6.7 10.4 5.5 5.9 10.7 4.5 8.1 11.4 5.9 5.2 8.3 | 5.8 6.7 10.4 5.5 5.9 10.7 4.5 8.1 11.4 5.9 5.2 8.3 | 5.8 6.7 10.4 5.5 5.9 10.7 4.5 8.1 11.4 5.9 5.2 8.3 | 5.8 6.7 10.4 5.5 5.9 10.7 4.5 8.1 11.4 5.9 5.2 8.3 |

Note: Event 1 = Penultimate Step; Event 2 = Contact; Event 3 = Follow Through
ject's right thigh angle as shown in Table 2 can be compared within and between subjects by type of kick and yard placement.

During the penultimate step foot plant, the right thigh angle should be at its largest because it is pulled back to provide room for the acceleration of the leg to kick the ball. The smallest mean angle was during the 35 yard toe kick for the penultimate step foot plant, it was $77.0^\circ$. The largest penultimate step foot plant average angle was during the 35 yard instep kick, $92.4^\circ$.

During the contact phase there should be a slight thigh angle, because the ball is kicked out in front of the body rather than under it. The average thigh angle at contact was $53.5^\circ$ for all kicks and distances.

The right thigh angle is an important factor in the follow through phase of the place kick because it is an indication of the subject's flexibility. It was measured at the highest point that the foot traveled following the kick. The mean right thigh angle for the toe kick at 20 yards was $-7.1^\circ$ with a standard deviation of 34.7 during the follow through. With the instep kick at 20 yards the mean right thigh angle was $-14.0^\circ$ with a standard deviation of 27.1 during the follow through. At 35 yards the toe kick mean was $-10.9^\circ$ and the standard deviation was 33.6 during the follow through. The instep kick mean was $-12.8^\circ$ with a standard deviation of 23.6.
Table 2
Average Thigh Angles Over Five Trials at the Penultimate Step, Ball/Foot Contact, and the Follow Through

<table>
<thead>
<tr>
<th>Subjects</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 yards</td>
<td>35 yards</td>
<td>20 yards</td>
<td>35 yards</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Events</td>
<td>Events</td>
<td>Events</td>
<td>Events</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subjects</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>86.4</td>
<td>61.7</td>
<td>37.2</td>
<td>89.7</td>
<td>67.1</td>
<td>31.2</td>
<td>86.7</td>
<td>52.8</td>
<td>25.3</td>
<td>91.8</td>
<td>67.0</td>
<td>21.5</td>
</tr>
<tr>
<td>B</td>
<td>73.7</td>
<td>38.2</td>
<td>-32.9</td>
<td>69.9</td>
<td>44.8</td>
<td>-47.8</td>
<td>92.8</td>
<td>64.6</td>
<td>-25.3</td>
<td>94.9</td>
<td>53.1</td>
<td>-26.9</td>
</tr>
<tr>
<td>C</td>
<td>80.9</td>
<td>49.5</td>
<td>-36.6</td>
<td>77.8</td>
<td>48.4</td>
<td>-24.6</td>
<td>86.6</td>
<td>42.7</td>
<td>-36.5</td>
<td>90.8</td>
<td>57.9</td>
<td>-29.7</td>
</tr>
<tr>
<td>D</td>
<td>72.8</td>
<td>46.1</td>
<td>3.8</td>
<td>70.6</td>
<td>43.9</td>
<td>-2.4</td>
<td>88.0</td>
<td>53.6</td>
<td>-19.4</td>
<td>92.1</td>
<td>64.9</td>
<td>-16.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toe</td>
<td>78.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Instep</td>
<td>48.9</td>
<td>9.6</td>
</tr>
</tbody>
</table>

Note: Event 1 = Penultimate Step; Event 2 = Contact; Event 3 = Follow Through
Knee

The right knee angle was measured by lines drawn from the greater trochanter of the hip to the condyle of the knee and from the knee to the lateral malleolus of the ankle. In Table 3 the right knee or kicking knee angles can be compared within and between subjects by type of kick and yard placement. The right knee angles are important throughout all phases of the kicking motion. It is important to have proper mechanics to apply adequate power, force, and velocity in the correct direction to the ball.

The average right knee angle across types of kicks and distances was 117.95° during the penultimate step foot plant. This angle greatly increases to about 180° during the contact phase.

The mean right knee angle at 20 yards for the toe kick was 176.0° with a standard deviation of 1.3 during the contact phase. At 20 yards for the instep kick, the mean right knee angle was 174.0° and a standard deviation of 10.5 during the contact phase. For 35 yards, the mean right knee angle was 164.8° for the toe kick and a standard deviation of 7.3 during the contact phase.

During the follow through the right knee angle stayed about the same as during the contact phase. The leg was generally straight throughout the follow through. The average angle for all styles and distances of the kicks was 174.95° during the follow through.
Table 3

Average Right Knee Angles Over Five Trials at the Penultimate Step, Ball/Foot Contact, and the Follow Through

<table>
<thead>
<tr>
<th>Kick</th>
<th>Toe</th>
<th>20 yards</th>
<th>35 yards</th>
<th>Instep</th>
<th>20 yards</th>
<th>35 yards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Events</td>
<td>Events</td>
<td>Events</td>
<td>Events</td>
<td>Events</td>
</tr>
<tr>
<td>Subjects</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>116.6</td>
<td>178.4</td>
<td>182.2</td>
<td>112.0</td>
<td>152.8</td>
<td>178.4</td>
</tr>
<tr>
<td>B</td>
<td>109.5</td>
<td>179.5</td>
<td>176.7</td>
<td>108.7</td>
<td>174.8</td>
<td>161.3</td>
</tr>
<tr>
<td>C</td>
<td>111.4</td>
<td>171.6</td>
<td>172.6</td>
<td>112.7</td>
<td>168.3</td>
<td>176.5</td>
</tr>
<tr>
<td>D</td>
<td>123.4</td>
<td>174.4</td>
<td>174.1</td>
<td>112.6</td>
<td>163.1</td>
<td>173.2</td>
</tr>
<tr>
<td>X</td>
<td>115.2</td>
<td>176.0</td>
<td>176.4</td>
<td>111.5</td>
<td>164.8</td>
<td>172.3</td>
</tr>
<tr>
<td>SD</td>
<td>6.8</td>
<td>1.3</td>
<td>4.2</td>
<td>1.9</td>
<td>7.3</td>
<td>9.0</td>
</tr>
</tbody>
</table>

Note: Event 1 = Penultimate Step; Event 2 = Contact; Event 3 = Follow Through
The left knee angle is a factor at the end of the penultimate step foot plant (support leg plant) due to its contribution to stability during the motion of the kicking. Table 4 shows the mean left knee angles which can be compared between subjects and within subjects for type of kick and yard placements. The mean left knee angles at 20 yards for the toe kick was 161.8° with a standard deviation of 9.8 during the support leg plant. The instep kick mean at 20 yards was 150.7° and a standard deviation of 6.1 during the support leg plant. At 35 yards, the toe kick mean was 159.1° and standard deviation of 9.4 during the support leg plant. The instep kick mean was 158.5° with a standard deviation of 6.0 during the support leg plant.

The left knee angles for contact and the follow through were less than at the penultimate step foot plant. The support leg tended to flex slightly during contact and stayed that way through the follow through. The average left knee angle for all kicks was 149.95° at contact and was 146.0° at the follow through.

**Velocity**

Average velocities were measured from the penultimate step foot plant, where the right foot would be at its farthest point back of the body to the ball/foot contact phase. The resultant velocity of the right foot (kicking foot) can be seen in Table 5.
Table 4

Average Left Knee Angles Over Five Trials at the Penultimate Step, Ball/Foot Contact, and the Follow Through

<table>
<thead>
<tr>
<th>Kick</th>
<th>Toe Events</th>
<th>20 yards</th>
<th>35 yards</th>
<th>Instep Events</th>
<th>20 yards</th>
<th>35 yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A</td>
<td>151.2</td>
<td>171.6</td>
<td>165.6</td>
<td>150.7</td>
<td>157.6</td>
<td>151.0</td>
</tr>
<tr>
<td>B</td>
<td>175.7</td>
<td>147.1</td>
<td>160.8</td>
<td>170.5</td>
<td>135.2</td>
<td>139.9</td>
</tr>
<tr>
<td>C</td>
<td>162.3</td>
<td>144.3</td>
<td>153.6</td>
<td>160.8</td>
<td>140.8</td>
<td>160.1</td>
</tr>
<tr>
<td>D</td>
<td>157.9</td>
<td>137.6</td>
<td>130.8</td>
<td>153.7</td>
<td>144.1</td>
<td>127.9</td>
</tr>
</tbody>
</table>

Subject X                      | 161.8      | 150.2    | 152.7    | 159.1         | 144.4    | 144.7    |

Note: Event 1 = Penultimate Step; Event 2 = Contact; Event 3 = Follow Through

| SD     | 9.8    | 14.2   | 15.4    | 9.4    | 10.0   | 14.3   | 10.2   | 6.1    | 10.9   | 6.0    | 7.4    | 15.8   |

Note: Event 1 = Penultimate Step; Event 2 = Contact; Event 3 = Follow Through
Table 5
Average Resultant Velocity of the Kicking Foot Over Five Trials

<table>
<thead>
<tr>
<th>Subject</th>
<th>20 Yards</th>
<th>35 Yards</th>
<th>20 Yards</th>
<th>35 Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>22.0</td>
<td>20.8</td>
<td>20.6</td>
<td>20.0</td>
</tr>
<tr>
<td>B</td>
<td>18.0</td>
<td>16.4</td>
<td>19.5</td>
<td>17.9</td>
</tr>
<tr>
<td>C</td>
<td>17.1</td>
<td>17.8</td>
<td>20.9</td>
<td>18.8</td>
</tr>
<tr>
<td>D</td>
<td>20.2</td>
<td>22.7</td>
<td>20.8</td>
<td>19.7</td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>19.3</td>
<td>19.4</td>
<td>20.4</td>
<td>19.1</td>
</tr>
<tr>
<td>SD</td>
<td>2.5</td>
<td>3.1</td>
<td>.6</td>
<td>.9</td>
</tr>
</tbody>
</table>
The velocities were compared within and between subject's styles of kicks as well as yard placements. The average velocity at 20 yards for the toe kick was 20.45 ft/s. The instep kick average at 20 yards was 19.33 ft/s. At 35 yards the toe kick average velocity was 19.1 ft/s. The average velocity was 19.43 ft/s at 35 yards using the instep kick.

The football velocities were measured from the point of ball/foot contact to the end of the follow through. Table 6 shows the football resultant velocities. The football velocities can be compared within and between subjects for types of kicks and yard placements. The 20 yard toe kick mean ball velocity was at 60.6 ft/s. The instep kick average velocity at 20 yards was 53.05 ft/s. The average ball velocity was 61.03 ft/s at 35 yards during the toe kick, and 54.25 ft/s with the instep kick.

**Displacement**

The displacement was measured in feet. All displacement is measured in a horizontal direction. Displacement for body position was measured by taking the horizontal displacement from the side view film for the position of the plant foot stance behind the ball. The plant foot displacement horizontally to the left of the ball was taken from the front view film.
Table 6
Average Resultant Velocity of the Football Over Five Trials

<table>
<thead>
<tr>
<th>Subject</th>
<th>Toe 20 Yards</th>
<th>Toe 35 Yards</th>
<th>Kick 20 Yards</th>
<th>Kick 35 Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>47.6</td>
<td>45.2</td>
<td>60.5</td>
<td>61.7</td>
</tr>
<tr>
<td>B</td>
<td>64.4</td>
<td>68.4</td>
<td>60.5</td>
<td>63.4</td>
</tr>
<tr>
<td>C</td>
<td>59.8</td>
<td>62.5</td>
<td>60.5</td>
<td>61.5</td>
</tr>
<tr>
<td>D</td>
<td>40.4</td>
<td>40.9</td>
<td>60.9</td>
<td>57.5</td>
</tr>
<tr>
<td>X</td>
<td>53.1</td>
<td>54.3</td>
<td>60.6</td>
<td>61.0</td>
</tr>
<tr>
<td>SD</td>
<td>10.7</td>
<td>13.0</td>
<td>.2</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Subject Position

The positional displacement of the subjects are given in Table 7 as the number of feet from the ball, laterally and posteriorly. The results in Table 7 can be compared within and between subjects for style of kick and yard placements. For the toe kicks at 20 yards and 35 yards, there was little displacement laterally to the ball. The average displacements were .83 ft for 20 yards and 1.28 ft for 35 yards. The standard deviations were 1.64 ft at 20 yards and .61 ft for 35 yards. Posterior displacement of the subject to the ball was about the same for both toe kicks at 20 and 35 yards at 9.03 ft and 9.01 ft respectively. The standard deviations were .78 ft at 20 yards and .70 ft at 35 yards.

The lateral displacement for the instep kick at 20 yards had an average of 3.37 ft and a standard deviation of 1.08 ft. At 35 yards the average lateral displacement was 4.61 ft and a standard deviation of .76 ft. The average posterior displacement was 8.09 ft for the 20 yard instep kick with a standard deviation of .88 ft. The 35 yard average posterior displacement was 7.64 ft with a standard deviation of .53 ft.

Ball

A field goal was considered successful if the football went through the uprights in this study. The first set of
### Table 7

Average Horizontal Displacement of the Subject, Laterally and Posteriorly From the Ball Between Stance and Support Foot Plant

<table>
<thead>
<tr>
<th>Subject</th>
<th>Motion</th>
<th>Motion</th>
<th>Motion</th>
<th>Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lateral Posterior (Feet)</td>
<td>Lateral Posterior (Feet)</td>
<td>Lateral Posterior (Feet)</td>
<td>Lateral Posterior (Feet)</td>
</tr>
<tr>
<td>A</td>
<td>.94</td>
<td>10.12</td>
<td>1.58</td>
<td>10.09</td>
</tr>
<tr>
<td>B</td>
<td>.22</td>
<td>9.15</td>
<td>.58</td>
<td>8.87</td>
</tr>
<tr>
<td>C</td>
<td>.89</td>
<td>8.81</td>
<td>1.03</td>
<td>8.78</td>
</tr>
<tr>
<td>D</td>
<td>1.24</td>
<td>8.01</td>
<td>1.93</td>
<td>8.28</td>
</tr>
<tr>
<td>X</td>
<td>.83</td>
<td>9.03</td>
<td>1.28</td>
<td>9.01</td>
</tr>
<tr>
<td>SD</td>
<td>1.64</td>
<td>.78</td>
<td>.61</td>
<td>.70</td>
</tr>
</tbody>
</table>
kicks were accomplished at 20 yards. A second set of kicks were from 35 yards. Results of the first set of kicks are as follows. Subject A kicked the instep kick first and had four successful kicks and one kick go wide to the left of the uprights. The second set of kicks was the toe kick for Subject A. All five kicks were successful. Subject B kicked the instep kicks first. All of subject B's kicks were considered successful, both toe and instep styles. Subject C kicked the toe kick first. The toe kicks were all successful at 20 yards. During the instep kick trials, one kick was unsuccessful and four went through the uprights. Subject D kicked the toe style first and had one unsuccessful and four successful kicks. The instep kicks were all wide to the left.

At 35 yards, Subject A kicked the instep kick first and all kicks were short. Two toe kicks were short and three were wide to the left. Subject B kicked the instep kick first and had four successful and one short. The toe kicks were short or wide left. Subject C did not have any successful kicks at 35 yards. The first three toe kicks were short, one kick was wide left, and one kick wide right. Subject D missed all kicks at 35 yards; all were short.

**Approach Angle**

The approach angle to the ball is the arcTangent of
the lateral displacement over the posterior displacement. The average approach angle was over five trials. The average angle of approach to the ball for each subject were given in Table 8. The results in Table 8 can be compared within and between subjects for style of kick and yard placements. At the 20 yard toe kick, the angle was 5.32° with a standard deviation of 3.04. The average instep kick at 20 yards was 22.76° with a standard deviation of 5.53. Both averages for the two styles at 35 yards were larger then those at 20 yards. The 35 yard toe kick average was 8.12° with a standard deviation of 3.96. The instep kick, 35 yard average was 31.81° with a standard deviation of 6.61.

Discussion

Angles

There were three angles measured in this study. They include the trunk angle, thigh angle, and right knee angle. All three angles will be discussed in this section.

Trunk

The trunk angle was measured with a vertical line and the line formed between the sternum and the crotch. Hay (1985) suggested a slight bend of the trunk from the start of the kick through ball/foot contact. This is done to allow the eyes to focus on the ball. In this study the
Table 8
Average Angle of Approach Over Five Trials From Stance to Support Foot Plant

<table>
<thead>
<tr>
<th>Subject</th>
<th>Toe 20 Yards (Degrees)</th>
<th>Toe 35 Yards (Degrees)</th>
<th>Instep 20 Yards (Degrees)</th>
<th>Instep 35 Yards (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.33</td>
<td>8.92</td>
<td>30.35</td>
<td>33.26</td>
</tr>
<tr>
<td>B</td>
<td>1.37</td>
<td>3.73</td>
<td>23.90</td>
<td>33.55</td>
</tr>
<tr>
<td>C</td>
<td>5.77</td>
<td>6.67</td>
<td>10.07</td>
<td>22.42</td>
</tr>
<tr>
<td>D</td>
<td>8.80</td>
<td>13.15</td>
<td>23.40</td>
<td>38.00</td>
</tr>
<tr>
<td>( \bar{X} )</td>
<td>5.32</td>
<td>8.12</td>
<td>22.76</td>
<td>31.81</td>
</tr>
<tr>
<td>SD</td>
<td>3.04</td>
<td>3.96</td>
<td>5.53</td>
<td>6.61</td>
</tr>
</tbody>
</table>
subjects had similar trunk angles from the penultimate step phase to the contact phase over each style of kick and yard placements. Leighty (1968) suggested after contact, the kicker should increase the trunk angle. By increasing the trunk angle the kicker's momentum will take him forward into the follow through rather than stopping after contact. This forward movement could prevent injuries to the back and legs. The forward movement also prevents the tendency for the kickers to want to lean back after contact. All four subjects in this study increased trunk angle slightly in the follow through phase for each set of kicks. The average increase of the trunk angles from contact to follow through was about 8.45° over all sets of kicks.

Thigh

The thigh angle was formed by a line drawn from the hip to the knee and a line drawn horizontally. During the penultimate step, the right knee (kicking leg) is flexed and hip extended which gives the greatest thigh angle throughout the kick. With the hip extended and knee flexed, the leg will move forward with more velocity and greater force (Blaettler, 1967). The more the leg is pulled back and bent, the more distance the football should be kicked. The average thigh angle for all kicks at the penultimate step phase was 88.65°.

During the contact phase, the thigh angle should be
reduced to zero (Hay, 1985). The thigh angles were measured at the beginning of the contact phase in this study and averaged 53.5°. Roberts and Metcalfe (1968) suggested that the foot is in contact with the ball for about .015s. The thigh angle was most likely less than 53.5° at the end of the .015s.

The thigh angle continues to decrease throughout the follow through phase. The leg continues to move in an upward direction which gives the thigh angle a negative number. The average thigh angle was -11.2°. Although there was variability seen in the average number of degrees per style of kick and yard placement, the follow through thigh angle was an indication of the subjects hamstring flexibility. If the subjects had not been flexible, the thigh angle would not have indicated as high a negative number.

Right Knee

As with the thigh angles, the more the knee is flexed during the penultimate step phase, the greater the velocity and more force generated towards contact (Blaettler, 1967). The average knee angle for all kicks during the penultimate step was 117.95°. The two distances of toe kicks had about a 7° smaller knee angle than the two instep kicks. The difference was made up with more hip rotation in the instep kick which increased the angular velocity of the leg (Stan-
The knee angle increased and moved toward full extension by the end of the contact phase. At the start of the contact phase, the average knee angle was 174.8° for all kicks. Knee angles were close to full extension during both styles of kicks.

During the follow through the knee remains straight if the kicker has good hamstring flexibility. If flexibility is absent, the knee tends to flex slightly. The average knee angle during follow through was 175°.

**Velocity**

The velocities of the kicking foot were measured from the penultimate step foot plant phase where the right foot was at the farthest point back of the body to the ball\foot contact phase. The velocity of the ball was measured from the contact phase to the end of the follow through phase. All velocities were measured in ft\s. Roberts and Metcalfe (1968) stated that when contact is good, the ball speed is 16 ft\s to 23 ft\s faster than the foot. In this study, the ball speeds were faster than the foot speeds for all kicks by 37.7 ft\s. That is well over the 16 ft\s to 23 ft\s found in Roberts and Metcalfe's study.

**Ball**

Horizontal displacement was used in the present study.
The ball's displacement was measured as 20 yards or 35 yards if it went through the uprights. The kicks were counted as successful or unsuccessful. At 20 yards 32 of 40 kicks (toe and instep) were successful. There were 19 successful toe kicks and 13 successful instep kicks at 20 yards. At 35 yards only 4 of 40 kicks were successful and they were all the instep style kicks. Manzi (1967) compared toe and instep style kicks and found that the instep style had greater accuracy at 20, 26, and 32 yards. He also found that the distance the ball traveled was the same or similar if two steps were taken with either style of approach.

The subjects in the present study had a more difficult time kicking the instep style at 20 yards compared to the toe style. At 35 yards all kicks were difficult. Only one subject was able to kick four successful trials and that was with his preferred style. Because the joint angles were on the average normal compared to the literature, it would appear that the problem might have been the ball\foot contact placement. Another cause for failure might have been that the subjects' leg strengths were not great enough to produce the velocity needed for the ball to travel 35 yards.

Subject Position

There is much controversy as to how far the kicker
should stand behind the ball before the approach. Blaettler (1967) suggested a one step approach which is about three feet behind the ball. Leighty (1968) suggested a step-and-a-half approach which is about 4.5 ft behind the ball. Hay (1985) stated that the kicker should decide what distance is comfortable but is generally 2 meters or 6.5 ft behind the ball. The average distance the subjects in the present study initially stood was about 9 ft for the toe kick at 20 and 35 yards. For the instep kick, the subjects were about 7.5 ft behind the ball.

There was no difference found in terms of distance in the literature for the toe kick versus the instep kick. The added distance that the subjects used in this study did not give them an advantage in terms of velocity of the ball or the distance the ball was able to be kicked (there were only four successful kicks at 35 yards).

During the instep kick trials there was a distance laterally that allowed the kicker to approach the ball with an arc motion to allow for hip rotation. There was not literature found that recommended the proper amount of distance to the left of the ball that the kicker should stand. The subjects in this study tended to side step one to two steps over once they were the proper distance behind the ball. The average distance to the left of the ball for all subjects was 3.99 ft. The subjects averaged about one foot farther to the left of the ball for the 35 yard instep
kick. Again the extra distance did not make the ball travel farther or faster.

Approach Angle

The angle of approach to the ball indicated similarities between subject's approaches if the displacements were different. There might be factors such as leg length or stride length that could increase or decrease a subject's displacement, but the angles of approach would still be similar. The angles of approach were larger for both of the styles at 35 yards when compared to 20 yards. Again there was no literature found that indicated a correct angle of approach but it would seem logical to think that the approach should be the same for every kick at any yardage. The toe kick's average angles were both under 10° and the instep's average angles ranged from 22° to 32°. The standard deviations ranged from 3.04 to 6.61 for the toe kick and instep kick, respectively, which indicated that all subjects' approaches were similar.
CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study biomechanically analyzed two styles of the football place kick; the toe kick and the instep kick. The study investigated kinematic variables of the lower extremities and trunk.

Five male subjects were to participate in this study but due to an injury only four were able to participate. All subjects were high school students and had varsity level experience in place kicking.

The place kicks were filmed using two Photo-Sonic 1-PL, 16mm cameras. The Vanguard Motion Analyzer projector was used to view the film after it was developed. A Neuromon 1224 digitizer was used to read the cartesian coordinates of selected points from the film to create a date file. The Peak Performance Measurement System Software Version 4.2 (Peak Performance Technologies, INC., 1990) created and calculated a data file, stick figures, joint angles, angular and linear velocities, and angular and linear acceleration.

Each subject completed five place kicks with each
style of kick at 20 yards and five place kicks with each style at 35 yards. The success of each kick was determined whether the ball went through the goal post uprights.

The computer program took each digitized point and formed lines with respective points to create stick figures. The joint angles were taken from the stick figures at each event frame. The event frames were: (a) penultimate step foot plant, (b) ball/foot contact, and (c) follow through.

Findings

There are several categories of findings that will be discussed in this section. They include: angles, velocity, and displacement.

Angles

The body angles measured are discussed in terms of style of kick, and yard placement. The findings are as follows:

1. The average trunk angle during the contact phase for the toe kick and the instep kick were between 266° and 267° at 20 yards.

2. The average trunk angle during the contact phase for the toe kick was 274° and the instep kick was 266° at 35 yards.

3. The trunk angle increased an average of 8.45° for
all subjects between the contact phase and the follow
through phase for both styles of place kick and both yards
placements.

4. At the penultimate step foot plant, the thigh
gle angle was at its largest for both styles of place kick and
both yard placements.

5. At the contact phase, the thigh angle was much
smaller than the penultimate step foot plant for both
styles and both yard placements.

6. In the follow through phase, the thigh angles
become negative due to the height that the leg reached
following each style of place kick and yard placements.

7. The average angle for the kicking knee (right
knee) was 118° during the penultimate step foot plant over
all kicks and yard placements.

8. The right knee angle increases to 180° during the
contact phase and only decreased slightly through the fol­
low through phase over all kicks and yard placements.

9. The non-kicking knee (left knee) was close to 180°
during the penultimate step foot plant for each style of
place kick and yard placement.

10. The left knee decreased slightly due to the flex­
ing of the knee for support in each style of the place kick
and yard placements while the right leg kicked the ball and
followed through.
Velocity

The velocity of the kicking foot and the football were as follows:

1. The average velocities of the kicking foot for both styles of the place kick were about 20 ft/s at 20 yards.

2. At 35 yards both styles of place kicks had average velocities of 19 ft/s.

3. The average ball velocity for the toe kicks at 20 yards and 35 yards was 60 ft/s.

4. The average ball velocity for both instep kicks at 20 yards and 35 yards was 53.5 ft/s.

Displacement

The displacement results between the ball and the subject laterally and posteriorly were as follows:

1. At 20 yards for both styles of kicks, were 8 of 40 kicks that were unsuccessful, 1 toe kick and 7 instep kicks.

2. At 35 yards, there were 4 of 40 kicks that were successful, 4 instep kicks.

3. Subjects lateral displacements (distance between ball and subject prior to approach) were small, .83 foot and 1.28 ft for the toe kicks at 20 and 35 yards, respectively.

4. The posterior position of the subject from the
5. There was a difference between the 20 yard lateral displacement and 35 yard lateral displacement for the instep kicks. They were 3.37 ft at 20 yards and 4.61 ft at 35 yards.

6. Posterior displacements for the instep kick were between 7.5 ft and 8 ft for 20 yards and 35 yards respectively.

7. The angle of approach varied between toe and instep kicks due to more lateral distance required to execute the instep kick.

8. The toe kick approach angles were 5.3° at 20 yards and 8.12° at 35 yards.

9. The instep kick approach angles were 22.76° at 20 yards and 31.81° at 35 yards.

Conclusions

The following conclusions were made:

1. In this study, there was a higher rate of success using the toe kick at 20 yards. There were 19 successful toe kicks and 13 successful instep kicks.

2. At 35 yards, only one subject had successful kicks and they were four instep style kicks. The subjects used in this study did not have the strength or power to kick 35 yard place kicks, toe style or instep style.

3. Biomechanically, the subjects had good techniques
in terms of joint angles and displacements, but velocities of the kicking foot and the ball were lower than what was found in the literature. This would indicate a lack of power and/or strength of the kicking leg to produce enough force on the ball.

4. This study indicated that the toe kick had better success than the instep kick at 20 yards. Therefore the toe kick would be the kick of choice for high school age kickers based on the findings from this study.

Recommendations

Leg strength would be an important aspect to consider when completing another study similar to the present study. Leg strength of the athlete interested in kicking may provide more information that would affect the style of place kicking the kicker chooses.

Future studies might consider investigating the angle of the ball as it is held prior to the kick. The angle might affect the placement of the foot on the ball at contact. Foot placement can affect the height of the kicked ball and therefore the distance the ball is kicked.

Future studies should also include many more subjects at different ages to obtain more reliable conclusions across different levels of competition.
Appendix A
Assent Form
Appendix A

Assent Form

This study is designed to biomechanically analyze the complex body movements involved in two types of place kicking: the toe kick and instep kick. The power, accuracy, and angle of flight of the football will be assessed.

The purpose of the study is to increase the knowledge already known regarding the two styles of place kicking. This study will lead to a better understanding of the complex body movements needed in each style of the place kick.

The study will be completed in one day and require approximately one to two hours of your time. The study consists of you completing ten kicks from 20 yards and ten kicks from 35 yards while being filmed. Immediately following your performance you will be asked how you felt about the quality of the kick. You will be given warm-up time as well as trial kicks.

The film will be viewed only by the researcher and the three committee members of this study. The film will be destroyed after one year following publication.

There may be minimal muscle discomfort from repeated place kicks. Should any abnormal discomfort or pain occur during your participation in the study, an athletic trainer will be on site to treat the symptoms.

All test data will be treated as confidential. Participation is voluntary, no penalty will be given in regards to team status if you decide to drop out of the study.

If an injury does require medical assistance you will be responsible for the medical bills. Any questions or concerns may be directed to KayLynn Albers during the day 772-1370 or Dr. Mary Dawson 387-8321.

subject's signature
Appendix B

Consent Form
Appendix B

Consent Form

This study is designed to biomechanically analyze the complex body movements involved in two types of place kicking: the toe kick and instep kick. The power, accuracy, and angle of flight of the football will be assessed.

The purpose of the study is to increase the knowledge already known regarding the two styles of place kicking. This study will lead to a better understanding of the complex body movements needed in each style of the place kick.

The study will be completed in one day and require approximately one to two hours of your time. The study consists of you completing ten kicks from 20 yards and ten kicks from 35 yards while being filmed. Immediately following your performance you will be asked how you felt about the quality of the kick. You will be given warm-up time as well as trial kicks.

The film will be viewed only by the researcher and the three committee members of this study. The film will be destroyed after one year following publication.

There may be minimal muscle discomfort from repeated place kicks. Should any abnormal discomfort or pain occur during your participation in the study, an athletic trainer will be on site to treat the symptoms.

All test data will be treated as confidential. Participation is voluntary, no penalty will be given in regards to team status if you decide to drop out of the study.

If an injury does require medical assistance you will be responsible for the medical bills. Any questions or concerns may be directed to KayLynn Albers during the day 772-1370 or Dr. Mary Dawson 387-8321.

________________________________________
parent's signature
Appendix C

Human Subjects Institutional Review Board Approval
Date: May 18, 1992
To: Kaylynn Albers
From: Mary Anne Bunda, Chair
Re: HSIRB Project Number 92-04-07

This letter will serve as confirmation that your research protocol, "The Biomechanical Analysis of Two Types of Place Kicks: the Toe and Instep Kick" has been approved after expedited review by a subcommittee of the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any change in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

xc: Dawson, Physical Education

Approval Termination: May 18, 1993
Appendix D

Filming Report
Appendix D
Filming Report

Research Project: Football place kicking

Date: 10-3-93  Location: Zeeland Stadium

Investigator: KayLynn Albers

Time Started: 12:00 pm  Time Completed: 2:00 pm

Camera #1: ASA 250  f/stop 16
Camera #2: ASA 250  f/stop 16

Light Conditions: Bright sunny day

Background: Chain link fence, trees

Reference Marks: Goal post and bleachers

Camera Speed Calibration: #1 100  #2 100

Camera Height: #1 3' 10"  #2 4'

Camera-Subject Distance: #1 134/179 ft  #2 103/148 ft

Subjects (number, joint markings): 5 subjects A-E with 12 joint markings

Filming Sequence: Subjects A and B did the toe kick first at 20 yards and 35 yards. Subject C and D did the instep kick first at 20 yards and 35 yards.

Comments: One subject was injured the night before the filming took place, so only four subjects took part in the study.

Miller & Nelson (1973)
BIBLIOGRAPHY


Sterner, M. J. (1966). The effectiveness of teaching the novice and soccer instep kick techniques as compared to the extra point in football. Unpublished master's thesis, South Dakota State University, Brookings, SD.

