A TIME COMPARISON AMONG THE CROSS-OVER STEP, THE JAB-STEP
AND TWO TYPES OF SPRINTER'S STARTS IN BASE STEALING

By

Richard Gay Israel

Approved by

Chairman, Thesis Committee

Committee Member

Committee Member

Committee Member

Chairman, Department of
Health and Physical
Education

Dean of Graduate School

VITA

NAME: Richard Gay Israel
PERMANENT ADDRESS: Route 2, Box 53, Dawson, Georgia
DEGREE AND DATE
CONFIRMED: M.A., 1974
DATE OF BIRTH: November 16, 1950
PLACE OF BIRTH: Americus, Georgia
SECONDARY EDUCATION: Terrell High School, Dawson, Georgia, 1968

<u>COLLEGES ATTENDED</u>	<u>DATES</u>	<u>DEGREE</u>	<u>DATE OF DEGREE</u>
Abraham Baldwin Jr. College Tifton, Georgia	1968-70	Associate of Science Physical Education	June, 1970
Appalachian State University Boone, North Carolina	1970-72	B.S.B., Health and Physical Education	June, 1972
Appalachian State University Boone, North Carolina	1973-74	M.A. Physical Education	August, 1974

MAJOR: Health and Physical Education

MINOR: Secondary Education

POSITIONS HELD: Teacher and Coach, Chesterfield High School,
Chesterfield, South Carolina - 1972-73.

Graduate Assistant, Dean of Men's Office,
Appalachian State University, Boone,
North Carolina - 1973-74.

310558

Archives
closed

LD

175

AMON

TH

315

A TIME COMPARISON AMONG THE CROSS-OVER STEP, THE JAB-STEP,
AND TWO TYPES OF SPRINTER'S STARTS IN BASE STEALING

A Thesis

Presented to

the Faculty of the Graduate School
Appalachian State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Health and
Physical Education

By

Richard Gay Israel

June, 1974

ABSTRACT

TITLE: A Time Comparison Among the Cross-Over Step, the Jab-Step, and Two Types of Sprinter's Starts in Base Stealing.

CANDIDATE: Richard Gay Israel

THESIS DIRECTED AND APPROVED BY:
Edward T. Turner, Ph.D.
Associate Professor of Health, Physical Education and Recreation

The purpose of the investigation was to compare four types of starts in order to determine the fastest method for optimum speed in base stealing. The subjects for the investigation were 10 varsity baseball players and 20 members of a physical education baseball skill and technique class at Appalachian State University. The four types of starts compared were the cross-over step, the jab-step, the sprinter's start from the base, and the sprinter's start with a lead. The subjects performed three repetitions of each type of start on the Appalachian State University baseball field.

The data was analyzed by a one-way randomized complete block design analysis of variance. A Tukey's w procedure was applied in order to locate the source of the significant difference. Analysis of the data revealed that the cross-over step start was significantly faster than the two types of sprinter's starts. Both the jab-step and the sprinter's start with a lead were significantly faster than the sprinter's start from the base. The results also revealed that no

significant differences existed between the cross-over and jab-step starts and that no significant difference existed between the jab-step and the sprinters start with a three foot lead.

Within the scope of the study the examiner concluded that the fastest starting techniques when stealing second base were the cross-over and the jab-step starts. A second conclusion reached was that the sprinters starts are the safest starts in relation to being picked off against the left handed pitcher. Finally, the examiner concluded that the sprinters start with a lead was proven to be a successful starting technique for use in stealing second base against the left handed pitcher in the game of baseball.

ACKNOWLEDGMENTS

The author would like to express appreciation for the guidance of Dr. Edward T. Turner, the thesis advisor.

The statistical analysis for this research was conducted under the capable and professional guidance of Dr. Jay T. Kearney. The aid rendered by Dr. Kearney was greatly appreciated.

The author wishes to acknowledge the patience and understanding of his wife, Karan.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	ii
LIST OF TABLES.	vi
LIST OF FIGURES	vii
Chapter	
I. INTRODUCTION	1
A. The Problem.	3
1. Statement of the Problem	3
2. Definition of Terms.	3
3. Scope of the Study	4
4. Limitations of the Study	5
II. REVIEW OF LITERATURE	6
A. Coaching Philosophies Related to Base Stealing	6
B. Research Related to Base Stealing Starts	9
C. The Starts	10
1. The Cross-Over Step Start.	11
2. Jab-Step Start	13
3. The Sprinters Start.	13
D. Summary.	17

Chapter	Page
III. PROCEDURES	18
A. Summary of Pilot Study	18
B. The Subjects	19
1. Selection of Subjects.	19
2. Grouping of Subjects	19
C. Measurement of Elapsed Time.	19
1. The Testing Device	19
2. Testing Procedure.	20
D. Statistical Analysis	25
IV. RESULTS AND DISCUSSION	26
A. Results.	26
1. Test-Retest Reliability.	26
2. Analysis of Elapsed Time Data.	27
B. Discussion	30
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY.	33
A. Summary.	33
B. Conclusions.	35
C. Recommendations for Further Study.	35
SELECTED BIBLIOGRAPHY	37
APPENDICES.	40
A. Diagram of Circuit	41
B. Table of Randomized Sequences of Starts and Red Lights for Group I	42
C. Table of Randomized Sequences of Starts and Red Lights for Group II.	43

APPENDICES (CONTINUED)	Page
D. Table of Randomized Sequences of Starts and Red Lights for Group III	44
E. Sample Data Sheet.	45
F. Table of Raw Test-Retest Data for Cross-Over Step Start.	46
G. Table of Raw Test-Retest Data for Jab-Step Start . .	47
H. Table of Raw Test-Retest Data for Sprinters Start From the Base.	48
I. Table of Raw Test-Retest Data for Sprinters Start With a Lead.	49
J. Table of Mean Scores for Subjects.	50

LIST OF TABLES

Table	Page
I. Test-Retest Reliability Coefficients.	27
II. Randomized Complete Block Design Analysis of Vari- ance Summary.	28
III. Results of Tukey's Test	29
IV. Recorded Pick-Offs.	30

LIST OF FIGURES

Figure	Page
I. Meylon Standard Electric Timer.	21
II. Light Board	21
III. Total Testing Circuit	21
IV. Cross-Over Step Start	24
V. Jab-Step Start.	24
VI. Sprinters Start From The Base	24
VII. Sprinters Start With A Lead Return To Base.	24

Chapter I

INTRODUCTION

"The game of baseball, as is true to a general extent in most other sports, bases the teaching of its skills primarily upon the experience and/or opinion of the coaches and players, often the professional ones."¹ The skills involved in base running are no exception.

The need for quality research in baseball is great. There are innumerable topic possibilities in the area of base running alone. Coaches not only neglect to conduct research in the area of base running, but often neglect the teaching of proper base running techniques taking for granted that the players are already highly skilled in that area.

Although the homerun is the most spectacular phenomenon in a baseball game very few college or high school coaches have homerun hitters. The high school or college coach does not have the homerun hitter for an attraction; however, the coach has players with adequate speed who thrill at taking chances. The public will not attend a listless game, but through exciting base running the coach can make the game an attraction.²

¹Donald K. Edwards and Franklin A. Lindeburg, "A Comparison of the Jab-Step vs. the Cross-Over Step in Running a Short Distance," Research Quarterly, 40:284, May, 1969.

²Archie P. Allen, Offensive Strategy and Techniques (Englewood Cliffs: Prentice-Hall, Inc., 1964), p. 67.

No other phase of base running is more exciting to the spectator than the steal. The steal is also a very strategic offensive baseball weapon. Watts stated that, "Running teams are usually successful ones going, in many cases, on the theory that when the other team can be made to throw the ball, there exists the possibility of an error which will enable the runner to advance."³ Dugan further explained that, "In amateur baseball there are many opportunities for the steal because of the throwing inaccuracy of the catchers and the inexperience of the pitchers."⁴ Finally, Case revealed that, "A good base runner will never be thrown out at second on an attempted steal as many times as he is forced at second by the hitter behind him."⁵ Coaches agree that the steal is a strategic offensive weapon; however, a minimum of research has been undertaken to provide the most efficient method of starting for optimum speed in base stealing.

Baseball coaches have stated that the cross-over step is the most efficient start for optimum speed in base stealing; however, the coaches do not base this theory on research but rather on past experience.^{6,7,8} Although most coaches agree that the runner should take a

³Lew Watts, The Fine Art of Baseball (Englewood Cliffs: Prentice-Hall, Inc., 1964), p. 302.

⁴Ken Dugan, How to Organize and Coach Winning Baseball (West Nyack, N.Y.: Parker Publishing Co., Inc., 1971), p. 79.

⁵George Case, "The Running Game," Mimeographed Sheet Received at National College Baseball Coaches Convention.

⁶Lew Watts, op. cit., p. 23.

⁷Virgil Ledbetter, Coaching Baseball (Dubuque, Iowa: William C. Brown Publishing Co., 1964), p. 46.

⁸Jack Coombs, Baseball, Revised by Danny Litwhiler (Englewood Cliffs: Prentice-Hall, Inc., 1967), p. 127.

smaller lead against the left hand pitcher, they do not foresee a necessity to change the type of start employed by the runner while attempting to steal against the left hander.

In this investigation the examiner explored four methods of starting in stealing bases. The investigator hoped that with an increased knowledge of the values of research that coaches will continuously pursue new and more efficient techniques to be employed in the game of baseball.

A. The Problem

1. Statement of the Problem

The purpose of the investigation was to compare four types of starts in order to determine the fastest method for optimum speed in base stealing.

Hypothesis Tested. The hypothesis tested was that no significant difference existed in elapsed time while sprinting from first to second base utilizing the cross-over step start, the jab-step start, the sprinters stance start from the base, and the sprinters stance start with a three foot lead.

2. Definition of Terms

Cross-Over Step Start. The cross-over step start was a start in which the runner was standing with his feet shoulder width apart. On the signal the runner rotated on the balls of his feet and simultaneously stepped across his right foot with his left foot in order to propel himself toward second base.

Jab-Step Start. The jab-step start was a start in which the runner was standing in ready position with his feet shoulder width apart. On the signal the runner stepped toward second base with his right foot as he rotated on the ball of his left foot. He then crossed his left foot over the right in order to propel himself toward second base.

Sprinters Stance Start From The Base. The sprinters stance start from the base was a start in which the runner began from first base in a sprinters stance. The hands were positioned shoulder width apart and the feet placed toe to heel with the non-dominant foot in contact with the base. In starting, the runner pushed off both feet and brought the non-dominant leg out first, a distance of three feet or less.

Sprinters Stance Start With a Lead. The sprinters stance start with a lead was a start in which the runner began in a sprinters stance with the back foot positioned three feet from first base. The hands were positioned shoulder width apart and the feet spaced toe to heel with the non-dominant foot back, positioned three feet from the base. In starting, the runner pushed off both feet and brought the non-dominant leg out first, a distance of three feet or less.

3. Scope of the Study

The subjects for the investigation were 30 male students at Appalachian State University, Boone, North Carolina, who ranged in age from 18 years 5 months to 27 years 5 months with a mean age of 20 years 5 months.

Included in the study were 10 members of the 1973-74 varsity baseball team at Appalachian State University, who ranged in age from

18 years 5 months to 20 years 10 months with a mean age of 20 years 2 months. Also included in the study were 20 members of a physical education baseball skill and technique class at Appalachian State University, who ranged in age from 18 years 9 months to 27 years 5 months with a mean age of 21 years 1 month.

The investigation was conducted during the Spring Quarter of the 1973-74 school year at Appalachian State University, Boone, North Carolina.

The subjects were electronically timed with a Meylon Standard Electric Timer while sprinting distances of 72, 76 and 78 feet. The subjects employed four types of starts--the cross-over step start, the jab-step start, the sprinters start from the base and the sprinters start with a three foot lead.

The data from the investigation was analyzed by computing a one-way randomized complete block design analysis of variance. A Tukey's w procedure was applied in order to find the source of the significant difference.

4. Limitations of the Study

The first limitation of the study was the inability of the subjects to master the movements involved in the sprinters start. Although the subjects were drilled for six weeks on the different starts, they were unable to master with optimum efficiency the movement patterns required for the sprinters start. A second limitation of the study was the examiner's inability to experiment with the four types of starts in actual game situations. In a game situation many variables exist which cannot be duplicated in a research investigation such as the jump the runner may take against the pitcher or the maximum lead he can safely take.

Chapter II

REVIEW OF LITERATURE

The literature reviewed in this chapter is related either directly or indirectly to the different types of starts employed in base stealing. The first area of reviewed literature reveals information pertaining to different coaching philosophies concerning the relevance of base stealing and the types of starts that coaches recommended. The second portion of the chapter is concerned with research studies comparing the efficiency of the different types of starts employed in base stealing. The final area discusses the basic mechanics of the cross-over, the jab-step, and the sprinters stance starts.

A. Coaching Philosophies Related to Base Stealing.

Very few college or high school coaches have homerun hitters; therefore, they must find other ways to make the game interesting and exciting. The public will not attend a listless game, but through exciting base running, the coach can make the game an attraction. The most exciting phase of base running to the spectator is the steal and it is also a very strategic offensive baseball weapon.¹

¹Archie P. Allen, Offensive Strategy and Techniques (Englewood Cliffs: Prentice-Hall, Inc., 1964), p. 67.

Watts stated that, "Running teams are usually successful ones going, in many cases, on the theory that when the other team can be made to throw the ball, there exists the possibility of an error which will enable the runner to advance."² Dugan further stated that, "In amateur baseball there are many opportunities for the steal because of the throwing inaccuracy of the catchers and the inexperience of the pitchers."³ Ledbetter explained that the steal was used to advance a runner without giving the defense an out and that a successful steal tended to upset the defense as well as to advance the runner.⁴ Finally, Case has stated that, "A good base runner will never be thrown out at second on an attempted steal as many times as he is forced at second by the hitter behind him."⁵

Many coaches agreed that a shorter lead should be taken against a left hand pitcher. Coombs revealed that left handed pitchers should be watched very closely because they often use body and leg movements to pitch to a batter that are almost identical with their movements for throwing to first base.⁶ Dugan also felt that a shorter lead

²Lew Watts, The Fine Art of Baseball (Englewood Cliffs: Prentice-Hall, Inc., 1964), p. 23.

³Ken Dugan, How to Organize and Coach Winning Baseball (West Nyack, N.Y.: Parker Publishing Co., Inc., 1971), p. 79.

⁴Virgil Ledbetter, Coaching Baseball (Dubuque, Iowa: William C. Brown Publishing Co., 1964), pp. 116-17.

⁵George Case, "The Running Game," Mimeographed Sheet Received at National College Baseball Coaches Convention.

⁶Jack Coombs, Baseball, Revised by Danny Litwhiler (Englewood Cliffs: Prentice-Hall, Inc., 1967), p. 128.

should be taken against the left hander and that extra caution should be taken to make sure that the pitcher is throwing toward home before the runner makes a move toward second.⁷ Finally, Allen stated that against the left handed pitcher the same basic lead-taking fundamentals must be observed but that a shorter lead should be taken in order to get a good start toward second. Allen further explained that a long lead would draw a throw from the pitcher which would cause the runner to lean back toward the base.⁸ Although coaches agree that a shorter lead should be taken against the left handed pitcher, they do not foresee a necessity to change the type of start employed by the runner while attempting to steal second against the left hander.

In reviewing the pertinent literature the investigator found that most coaches agree that the cross-over step start should be utilized by the runner for optimum performance in base stealing. Watts, Alston, Allen, Dugan and Coombs all agreed that the cross-over step start should be employed by the base runner after he takes his lead.^{9,10,11,12,13}

⁷Dugan, loc. cit.

⁸Allen, op. cit., p. 77.

⁹Watts, loc. cit.

¹⁰Walter Emmons Alston, The Complete Baseball Handbook (Boston: Allyn and Bacon, Inc., 1972), p. 81.

¹¹Allen, loc. cit.

¹²Dugan, loc. cit.

¹³Coombs, loc. cit.

Siedentop and Kaat disagreed with other coaches and stressed the jab-step as the most efficient type of start to be employed in base stealing.¹⁴ Finally, Reiff suggested that the relative merits of the cross-over step or the jab-step starts were unimportant when compared with the art of obtaining a walking lead.¹⁵

B. Research Related to Base Stealing Starts

Most coaches agreed that the cross-over step was the most efficient start for optimum speed in base stealing; however, they based their opinions on past experience and not on research findings. This portion of the chapter contains studies that related directly to the types of starts employed in base stealing.

A study by Edwards and Lindeburg which compared the jab-step and the cross-over step starts revealed that the cross-over step was significantly faster than the jab-step at distances of 5, 11, 22, and 37 feet. The authors further concluded that because spiked baseball shoes could produce different results due to the resistance during a pivot, further investigation in the area was necessary. The subjects for Edwards and Lindeburg's study were 30 boys, ages 13-17, who were volunteers for the study. Four chronoscopes were used to time the subjects at four timing stations. The clocks were started simultaneously, being connected to a single switch in the form of a pressure plate. The subjects were timed

¹⁴Daryl Siedentop and Jim Kaat, Winning Baseball, Science and Strategies (Glenview, Ill.: Scott, Foresman and Co., 1971), p. 55.

¹⁵Guy G. Reiff, What Research Tells The Coach About Baseball (American Association of Health, Physical Education and Recreation, 1201 16th Street N.W., Washington, D.C.), p. 30.

at distances of 5, 11, 22, and 37 feet. Reliability coefficients, ranging from .988 to .998, using the split-half method (odd vs. even trials) were obtained in each instance for both movements and for each testing station.¹⁶

In a letter of correspondence Buzzy Keller, the Director of Research at the Kansas City Royals Baseball Academy, stated, "We have done some research in this area and find that the type of maneuver used on the first step of the break is determined by each individual player's thrust or dominant foot. We find that about fifty percent of the players are right-footed and should use a jab-step as opposed to the conventional cross-over method."¹⁷

In summation, the available research findings reviewed in this chapter comparing the cross-over and jab-step starts were found to be contradictory. The examiner was unable to find literature which considered the sprinters stance as a possible starting position to be utilized in base stealing.

C. The Starts

This portion of the chapter contains literature related to the basic mechanics of the cross-over step, the jab-step, and the sprinters stance starts.

¹⁶D. K. Edwards and F. A. Lindeburg, "A Comparison of the Jab-Step vs. the Cross-Over Step in Running A Short Distance," Research Quarterly, 40:284, May, 1969.

¹⁷Buzzy Keller, Director, Kansas City Royals Baseball Academy, Letter of Correspondence, February 25, 1974.

1. Cross-Over Step Start

With the cross-over step start the emphasis is upon getting a good lead and then starting as quickly as possible. Coombs explained, "That base stealing does not necessarily call for a big lead off first base from which a steal might be attempted. The ability to make a quick get away, as a track man would term it, is the main qualification of a good base stealer."¹⁸

Dugan stated that after taking his lead, the base runner should assume a crouched position with his legs comfortably spread, feet parallel, hands on knees, and weight on the balls of the feet.¹⁹ Watts explained that the runner should take a lead by backing off the bag and then face the pitcher with the feet spread and weight evenly distributed on the balls of the feet.²⁰ Finally, Allen stated that, "Against the left-handed pitcher the same basic lead taking fundamentals must be observed, but a shorter lead will be necessary in order to get a good start to second."²¹

The cross-over step is accomplished by a quick pivot on the right foot, after which the left foot crosses over the right leg. The body remains low, particularly at the instant of the start when the head and shoulders are thrown toward second base, and then the base runner gradually assumes the natural running position.²²

¹⁸Coombs, loc. cit.

¹⁹Dugan, loc. cit.

²⁰Watts, op. cit., p. 23.

²¹Allen, op. cit., p. 61.

²²Coombs, loc. cit.

Alston described the cross-over step mechanics as follows:

The base runner should break for the base at the precise second the pitcher begins his move to the plate. Most runners prefer their first move toward second base to be a cross-over step. When they decide to go, they just pivot on the right foot and cross-over with the back foot. They should shove off for second on the left foot while pivoting on the right foot. One's weight should be forward with his legs driving hard. In shoving off for second, he should swing his left arm toward the next base in the same way a boxer throws an uppercut. This helps him to cross-over. The arm action pulls his body around and enables him to take a good first stride with his left foot.²³

Maury Wills stated, "I always remember to keep my body moving."²⁴

Wills explained that a runner could get away faster when he is in motion rather than standing still. The idea was to keep the feet shuffling back and forth, bending at the knees and trying to keep the weight on the balls of the feet.²⁵

A statement by Bunn was found to be in agreement with Wills' theory of keeping the body in motion. Bunn stated that, "Newton's first law suggested that a base runner would stand a better chance of stealing a base if he could be in motion before the pitch."²⁶ Bunn felt that the effort to overcome inertia was much greater than the effort to speed up after the body was already in motion.²⁷

²³Alston, loc. cit.

²⁴Ibid., citing Maury Wills, p. 82.

²⁵Ibid.

²⁶John Bunn, Scientific Principles of Coaching (Englewood Cliffs: Prentice-Hall, Inc., 1959), p. 119.

²⁷Ibid.

2. Jab-Step Start

With the jab-step start in stealing bases, the emphasis is upon getting a good lead and then starting as quickly as possible. Siedentop and Kaat explained that once the desired lead-off is achieved, the base runner must be concerned with getting the quickest possible start toward the next base. The authors further stated that the first step should be long and low and that the upper torso should be thrown toward second base. They also revealed that this technique had been shown to be the fastest most efficient way to initiate movement.²⁸

The jab-step is accomplished by pushing off the left foot and moving the right foot a short distance to the right. After this is accomplished, the left foot should then cross over the right and the shoulders should be thrown toward second base. The body should remain low particularly at the instant of the start. The runner should push hard off the left foot and throw the right arm back and the left arm across the front of their bodies to help the upper torso spin around toward second base.²⁹

3. The Sprinters Start

To the examiner's knowledge, the sprinters start had never been considered or tested as a possible starting position in base stealing. In the sprinters stance start the emphasis is upon getting away from the mark as quickly as possible. Bunn stated, "That the ideal starting position is the one that permits the greatest amount of force to be exerted over the longest distance in the desired direction, in order to overcome

²⁸Siedentop and Kaat, loc. cit.

²⁹Ibid.

inertia. It must also be the position in which the runner's equilibrium is the least stable in the desired direction, so that he will start as quickly as possible."³⁰ The aim is to exert the greatest force over the longest distance in the shortest period of time.

In initiating the sprinters start the center of gravity should be as high as possible and over the edge of the base in the direction of the desired movement. From the crouch start, the hips should be higher than the shoulders so that the center of gravity of the body is thrown forward toward the hands and in front of the feet. This position takes advantage of the force of gravity in speeding the starting movement.³¹

The exact position in which the body can exert the greatest amount of force has been the subject of considerable experimentation. White studied hip elevation to determine its effect on starting time in sprints. In the bunch start, he found that the fastest start was effected when the line of the hips and shoulders was 27 degrees above the horizontal, the hips being higher than the shoulders.³²

Dickerson studied the relationship between foot spacing, starting time, and final speed in sprinting. He found that the bunch start, wherein the toe of the rear foot is opposite the heel of the front foot, was significantly the fastest.³³

³⁰Bunn, loc. cit.

³¹Ibid., p. 120.

³²R. A. White, "Effects of Hip Elevation on Starting Time in the Sprint," Research Quarterly Supplement, 6:129, October, 1935.

³³A. D. Dickerson, "Relationship Between Foot Spacing, Starting Time, Speed in Sprinting, and Physical Measurements" (Master's Thesis, University of Iowa, 1938), cited by John W. Bunn, Scientific Principles of Coaching (Englewood Cliffs: Prentice-Hall, Inc., 1959), p. 120.

Henry and Stock found that the starting position depends somewhat on the build of the runner. The researchers found that the runner should assume a starting position from which his center of gravity is higher than his shoulders and is well forward to allow as much force as possible to be exerted in a horizontal direction. They found that the feet should be back far enough from the starting line so that the direction of thrust is not upward but forward. The spread of the feet should not be so great that the optimum thrust cannot be attained.³⁴

Bresnahan explained that speed in starting depends upon which foot is forward in the starting position. Right handed athletes should start with the left foot forward and left handed ones with the right foot forward. If this position was reversed the starting time was slower.³⁵

As the runner starts he should not straighten because he needs to follow the direction of his push. His movement should be as horizontal as possible which prevents the waste of force. As the left leg moves forward, the right arm should be brought forward sharply. The principle that the momentum of the part is transferred to the whole applies here.³⁶

³⁴Franklin M. Henry and Malcolm Stock, "Force-Time Character of Sprint Start," Research Quarterly, 23:301-06, October, 1952.

³⁵G. T. Bresnahan, "A Study of the Movement Pattern in Starting a Race from the Crouched Position," Research Quarterly Supplement, 5:5-11, March, 1934.

³⁶*Ibid.*

The runner gains speed only while his feet are pushing against the ground; therefore, he should take relatively short strides when greater acceleration is needed, and increase his stride as top speed is reached.³⁷ Cureton found that if the first step is less than three feet in front of the starting line, faster starting is accomplished.³⁸

In summation, the aim of the sprinters start is to exert the greatest force over the longest distance in the shortest period of time. The dominant or jumping foot should be forward with the feet spaced toe to heel. The hands should be shoulder width apart and placed far enough in front so that the hips are four inches higher than the shoulders which should place from fifty to sixty percent of the body weight on the hands.

In starting, the runner should push off with both feet and then bring the non-dominant leg out first. The first step should be three feet or less. As the leg comes forward the opposite arm should come forward and then back as the opposite leg comes forward. Arm action is very important. The arms should be pumped straight up and down with the elbows slightly brushing the body. As the runner starts he should not straighten because he needs to follow the direction of his push. And finally, the runner's movement should be as horizontal as possible to avoid the waste of force.

³⁷Ibid.

³⁸T. K. Cureton, "Mechanics of Track Racing Start," Scholastic Coach, 5:30, January, 1935.

The mechanics of the sprinters stance start discussed in this portion of the chapter dealt basically with the runner in the static sprinter's position; however, in this investigation the runners utilized the hip rocking technique which enabled them to overcome inertia much faster. The runner was positioned in a squatting ready position. As the pitcher stretched the runner began to slowly move his hips upward so that at the exact moment the pitcher moved toward home plate the runner's hips were four inches higher than the shoulders and the runner was able to start faster because his body was already in motion.

D. Summary

The literature revealed that the general consensus of professional opinions indicated that the cross-over step start was the most efficient start for optimum speed in base stealing. The related research studies reviewed were found to be in contradiction on the question of the most efficient start for base stealing. The literature revealed the need for further study in the area of base stealing.

Chapter III

PROCEDURES

Included in this chapter is a summary of the pilot study and a discussion related to the subjects. A discussion of the testing procedures and information concerning the statistical treatment of the data are also included.

A. Summary of the Pilot Study

The pilot study was conducted on February 26, 1974 at Appalachian State University. The purpose of the preliminary investigation was to test the operational efficiency of the equipment and to make decisions concerning the type of testing procedures to employ in this investigation.

As a result of the pilot study, the examiner recognized the necessity to add an additional stop gate 12 feet beyond the first stop gate because the runners were decelerating before they had broken the circuit at the first stop gate. Also revealed was the necessity to randomly select the type of start the subject utilized each time and to randomly select the red light sequence that each subject received during the testing period. The final observation indicated that the subjects must be trained in order to more efficiently perform the different starts prior to the initial testing date.

B. The Subjects

1. Selection of Subjects

The subjects for the investigation were 10 varsity baseball players at Appalachian State University, who ranged in age from 18 years 5 months to 20 years 10 months with a mean age of 20 years 2 months. Also included in the study were 20 members of a physical education baseball skill and technique class at Appalachian State University, who ranged in age from 18 years 9 months to 27 years 5 months with a mean age of 21 years 1 month. The subjects were chosen because of their interest in the game of baseball and because of their desire to take part in the study.

2. Grouping of Subjects

The subjects were divided into three groups with 10 people in each group for the testing period in order to allow each subject an 8 minute recovery period after each trial. The recovery period was allowed in order to assure that fatigue would not affect the results. The groups were divided according to the subjects time availability in order to take part in the testing procedure on the testing date.

C. Measurement of Elapsed Time

1. The Testing Device

The subjects were electronically timed with a Meylon Standard Electric Timer arranged in a six volt circuit consisting of the timer, two six volt dry cells, three single post single throw switches, two six volt bulbs, four standards, two stop gates, and 200 feet of six volt wire.

Figure I illustrates the Meylon Standard Electric Timer while Figure II illustrates the light board, the six volt dry cells, and the timer. Finally, illustrated in Figure III is the entire testing device circuit including the light board, the stop gates, and the timer.

The circuit was arranged in order to provide a master switch for the entire circuit while the two stop switches were arranged in order to allow the examiner to control the sequence of the red and green lights. The lights were wired in parallel and connected to the timer in parallel. The circuit continued from the light board to the stop gate and back to the dry cells and was arranged so the main switch illuminated the light and simultaneously activated the timer. As the runner broke the stop gate the timer was automatically stopped and the elapsed time recorded. The second stop gate was not wired into the circuit; however, the subjects were not informed about this in order to assure that the runners maintained optimum speed through the first stop gate. Appendix A, page 41 contains a detailed diagram of the timing circuit.

The investigation was conducted on the Appalachian State University baseball field which was in good playing condition for the study. The subjects wore baseball spikes and sweat suits. The subjects ran from first to second base in a direct line. The light board and clock were placed on a table positioned 10 feet from the pitching rubber and positioned directly between first base and the mound in order for the subjects to have a clear view of the light board.

2. Testing Procedure

As previously stated, the subjects were divided into three groups with 10 subjects in each group. Appendix B, C, and D contain the randomized

FIGURE I.

MEYLON STANDARD ELECTRIC TIMER

FIGURE II.

LIGHT BOARD

FIGURE III.

TOTAL TESTING CIRCUIT

sequences of starts that the subjects utilized and the randomized red light sequences that occurred.

The starting point for the subjects executing the cross-over and jab-step starts was a line six feet from first base on which the left foot was planted. The starting point for the subjects utilizing the sprinters start with a three foot lead was a line three feet from first base which was contacted with the toe of the runner's foot as he assumed the sprinters stance position. Finally, the starting point for the execution of the sprinters start from the base was with the back foot in contact with the base as the runner assumed the sprinters stance position.

The stop gate was located 12 feet from second base because under normal game conditions the runner decelerated for the slide at this point. Therefore, the sprinting distance while executing the cross-over step and jab-step starts was 72 feet, while the distance for the sprinters stance start with a three foot lead was 75 feet and the distance for the sprinters start from the base was 78 feet.

Preceding each trial the subjects were told which type of start to perform. Figure IV illustrates the cross-over step start in which the runner was standing with his feet shoulder width apart and the weight on the balls of his feet. On the signal the runner rotated on the balls of his feet and simultaneously stepped across his right foot with the left in order to propel himself toward second base.

Figure V illustrates the jab-step start in which the runner was standing in ready position with his feet shoulder width apart. On the signal the runner stepped toward second base with his right foot as he

rotated on the ball of his left foot. He then crossed his left foot over the right in order to propel himself toward second base.

Illustrated in Figure VI is the sprinters stance start from the base. The sprinters stance start from the base was a start in which the runner began from first base in a sprinters stance. The hands were positioned shoulder width apart and the feet placed toe to heel with the non-dominant foot in contact with the base. In starting the runner pushed off both feet and brought the non-dominant leg out first a distance of three feet or less.

The sprinters stance with a lead was a start in which the runner began in a sprinters stance position with the back foot positioned three feet from first base. The hands were placed shoulder width apart and the feet spaced toe to heel with the non-dominant foot back. In starting, the runner pushed off both feet and brought the non-dominant leg out first, a distance of three feet or less.¹

The starting signal was the illumination of the green light on the light board; however, if the red light was illuminated, the subject was forced to return to the base. When the subject broke for second base on the red light a distance of three feet or more a "pick-off" was recorded. The method of returning to the base utilized by the runner while executing the cross-over and jab-step starts was of no concern to the examiner; however, Figure VII revealed the technique devised to return to the base while utilizing the sprinters start with a three foot lead.

¹For a more detailed description of the starts see the Review of Literature, page 6.

FIGURE IV.

CROSS-OVER STEP START

FIGURE V.

JAB-STEP START

FIGURE VI.

SPRINTER'S START FROM THE BASE

FIGURE VII.

SPRINTER'S START WITH A LEAD-
RETURN TO THE BASE

In order to return to the base while utilizing the sprinters start with a three foot lead the back foot was extended until it contacted the base.

After each trial the subjects time was recorded in the appropriate column on the data sheet listed in Appendix E, page 45. Each start was executed three times. In the event the runner was picked off, a recording was made in the appropriate column on the data sheet.

D. Statistical Analysis

The data were analyzed by first computing the mean times of each subject for the four types of starts. After the means were computed the data was analyzed by a one-way randomized complete block design analysis of variance. Finally, a Tukey's w procedure was applied in order to find the sources of the significant differences.

Chapter IV

RESULTS AND DISCUSSION

Included in this chapter is a presentation and discussion of the results of the investigation. For the reader's convenience the chapter is divided into two sections. The first portion contains the results of the test-retest reliability computation and an analysis of the elapsed time comparison data while the final portion contains a discussion of the results of the study.

A. Results

A one-way randomized complete block design analysis of variance was used to analyze the data. The analysis of variance indicated whether significant differences existed among the four groups of data. When the data indicated a significant difference the Tukey's w procedure was applied in order to determine the source of the significant difference.

1. Test-Retest Reliability

After the testing procedure was completed, five subjects were randomly selected and retested on each of the four types of starts. The means of the subjects times during the test were compared to the retest data.

Test-retest reliability was verified by a Pearson product-moment correlation coefficient and with 18 degrees of freedom a composite

correlation coefficient of $r=.962$ was obtained. Table I presents the correlation coefficients for each of the four types of starts.

Table I
TEST-RETEST RELIABILITY COEFFICIENTS

Starts	N	df	r
Cross-Over	5	3	.962*
Jab-Step	5	3	.981*
Sprint With Lead	5	3	.998*
Sprint From the Base	5	3	.990*
Composite	20	18	.962**

* Level required for significance at $\alpha = .05$ with 3 df was .878.

** Level required for significance at $\alpha = .05$ with 18 df was .444.

2. Analysis of Elapsed Time Comparison Data

An F-ratio of 16.52 was found by computing the one-way randomized complete block design analysis of variance. Table II is the summary table for the ANOVA.

Table II
RANDOMIZED COMPLETE BLOCK DESIGN ANALYSIS OF VARIANCE SUMMARY

Source	df	SS	MS	F
Block	29	5.7930	.1998	
Treatment	3	.2477	.0826	16.52*
Error	87	.4370	.0050	
Total	119	6.4777		

* F required for significance at $\alpha = .05$ with 3/87 df = 2.72.

A Tukey's w procedure was applied to the data in order to find the sources of the significant differences. Table III contains the results of the Tukey's w procedure computed at the $\alpha = .05$ level. The results revealed that the cross-over step start was significantly faster than both the sprinters start with a lead and the sprinters start from the base. Both the jab-step and the sprinters start with a lead were significantly faster than the sprinters start from the base.

Table III
RESULTS OF TUKEY'S TEST

Starts	Means	Differences Between the Means		
		Jab-Step	Sprint From Base	Sprint With Lead
Cross-Over	4.0117	.0013	.1160*	.0523*
Jab-Step	4.0230		.1047*	.0410
Sprint From Base	4.1277			.0637*
Sprint With Lead	4.0640			

* Significant difference at $\alpha = .05 \times df$.

The results revealed that no significant difference existed between the cross-over and the jab-step starts. Finally, the results revealed that no significant difference existed between the jab-step and the sprinters start with a three foot lead.

As the subjects utilized both types of sprinters starts no pick offs were recorded; however, as the subjects employed the cross-over technique nine pick offs were recorded and three pick offs were recorded for the jab-step technique. The pick off data is presented in Table IV.

Table IV
RECORDED PICK OFFS

	Cross-Over	Jab-Step	Sprint With Lead	Sprint From Base
Pick Offs	9	3	0	0
Total Trials	90	90	90	90

B. Discussion

The results of the study were found to be in conflict with the results of a similar study by Edwards and Lindeburg in which the authors found the cross-over step start to be significantly faster than the jab-step start; however, the authors pointed out that the results could have been affected because the subjects were not wearing baseball spikes. In this investigation the problem was alleviated by having the subjects wear baseball spikes and as a result no significant difference was found between the cross-over and jab-step starts.¹

The results of the investigation were in agreement with findings by officials at the Kansas City Royals Baseball Academy which revealed that leg dominance determined whether the runner should use the cross-over or jab-step starts. The Royals officials further elaborated that no significant difference in elapsed time existed between the two starts.²

¹Donald K. Edwards and Franklin A. Lindeburg, "A Comparison of the Jab-Step vs. the Cross-Over Step in Running a Short Distance," Research Quarterly, 40:284, May, 1969.

²Buzzy Keller, Director, Kansas City Royals Baseball Academy, Letter of Correspondence, February 25, 1974.

As the subjects utilized both types of sprinters starts no pick offs were recorded; however, as the subjects employed the cross-over technique nine pick offs were recorded and three pick offs were recorded for the jab-step technique. The pick off results could influence the coach's philosophy in that the runner could be expected, while utilizing the sprinters start, to be picked off less; therefore, his probability of reaching second safely would increase.

Many variables exist which could affect the validity of employing the sprinters start with a lead in base stealing. First the height of many runners would allow them to take a much larger lead than three feet and would thus decrease the sprinting distance and proportionately decrease elapsed time. The cross-over step was .0523 seconds faster than the sprinters start; however, the sprinting distance for the sprinters start was three feet longer than the cross-over. The taller runner could greatly reduce the difference in elapsed time between the two variables.

In actual game situations many runners, while executing the cross-over and jab-step starts against the left handed pitcher, tend to hesitate and many times make a move back toward first base. As the left handed pitcher delivers to the plate the right knee is brought around toward first base and this motion with the knee causes the runner to hesitate. While utilizing the sprinters start with a lead the runner would not have to worry about the pitcher's motion as much as the runners utilizing the jab-step and cross-over step starts; therefore, the runner could start faster while utilizing the sprinters start with a lead.

A similar investigation utilizing sprinters as subjects could yield different results. Although the subjects were drilled for six weeks on the different starts, they were unable to master with optimum efficiency the movement patterns required by the sprinter's start. If taught from the early years, the sprinter's start could become the fastest starting technique for optimum speed in base stealing.

In this investigation the difference in the mean times for the cross-over step was .1160 of a second faster than the mean time for the sprinter's start with a three foot lead. If a subject sprinted the distance in four seconds, this would mean he was running at 18 feet per second and in .1160 of a second he would cover only 1.55 feet. This difference is very small and in a game situation it is possible that the difference of .1160 of a second would have some affect on the runner's ability to steal safely.

The feasibility of utilizing the sprinter's start in base stealing would be enhanced against the left-handed pitcher. Since the runner normally takes a shorter lead against the left-handed pitcher the sprinting distance would be longer; therefore, the sprinter's start with a lead could be utilized without a significant loss in elapsed time. The chances of the runner's being picked off by the left-handed pitcher would also increase. Since the sprinter's starts were found to be the safest starts in relation to being picked off the feasibility of utilizing the sprinter's starts against a left-handed pitcher would also increase because of pick offs.

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

Included in this chapter is a summary of the investigation. Also included are the conclusions and the recommendations for further study.

A. Summary

The purpose of the investigation was to compare four types of starts in order to determine the fastest start for optimum speed in base stealing. The four types of starts compared were the cross-over step-start, jab-step start, sprinters start from the base and the sprinters start with a three foot lead.

The subjects for the investigation were 10 varsity baseball players, who ranged in age from 18 years 5 months to 20 years 10 months with a mean age of 20 years 2 months. Also included in the study were 20 members of a physical education baseball skill and technique class at Appalachian State University. The subjects were chosen because of their knowledge of the game of baseball and their desire to take part in the investigation.

The subjects were electronically timed with a Meylon Standard Electric Timer arranged in a six volt circuit consisting of the timer, two six volt dry cells, three single post single throw switches, two six volt bulbs, four standards, two stop gates and 200 feet of six volt wire.

The subjects were divided into three groups of $N = 10$ subjects. The types of starts the subjects used were randomized before the testing period as were the red light sequences that occurred.

The starting point for the subjects executing the cross-over and jab-step starts was a line six feet from first base on which the left foot was planted. The starting point for the subjects utilizing the sprinters start with a three foot lead was a line three feet from first base which was contacted with the toe of the runner's back foot as he assumed the crouched sprinter's position. Finally, the starting point for the execution of the sprinter's start from the base was with the back foot in contact with the base.

The stop gate was located 12 feet from second base; therefore, the sprinting distance while executing the cross-over step and jab-step starts was 72 feet, while the distance for the sprinters start with a three foot lead was 75 feet and the distance for the sprinters start from the base was 78 feet.

Preceding each trial the subjects were told which type of start to perform. The starting signal was the illumination of the green light; however, if the red light were illuminated the subject was forced to return to the base. The subjects performed three trials of each starting technique and after each trial the elapsed time was recorded in the appropriate column on the data sheet.

The data were analyzed by first computing the mean times of each subject for the four types of starts. After the means were computed the data was analyzed by a one-way randomized complete block analysis of variance. Finally, a Tukey's w procedure was applied in order to locate the sources of the significant differences.

An F ratio of 16.52 was found by computing the one-way randomized complete block design analysis of variance. The results of the Tukey's w procedure revealed that the cross-over step start was significantly faster than both the sprinter's start with a lead and the sprinter's start from the base. Both the jab-step and the sprinter's start with a lead were significantly faster than the sprinter's start from the base.

The results also revealed that no significant difference existed between the cross-over and jab-step starts and that no significant difference existed between the jab-step and the sprinter's start with a three foot lead.

B. Conclusions

Within the scope of the investigation the following conclusions were warranted: (1) The fastest starting techniques for stealing second base are the cross-over and jab-step starts; (2) The sprinter's starts are the safest starts in relation to being picked off; and (3) The sprinter's start with a lead was proven to be a successful starting technique for use in stealing second base in the game of baseball.

C. Recommendations for Further Study

As a result of the study comparing the elapsed times, the cross-over step, the jab-step, and two types of sprinter's starts in base stealing, the following suggestions for investigation are indicated: (1) A study duplicating this investigation using sprinters as subjects should be

undertaken because the sprinters would be able to more efficiently execute the sprinters start; (2) A study comparing the relationship of leg dominance to time comparisons of the cross-over and jab-step starts in order to determine if leg dominance was related to the type of start utilized should be undertaken; and (3) A study duplicating this investigation allowing the subjects to maintain a sprinters start with a lead related to their height and leg reach should be undertaken because this would decrease the sprinting distance and proportionately decrease the elapsed time.

SELECTED BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

A. BOOKS

- Allen, Archie P., Offensive Strategy and Techniques (Englewood Cliffs: Prentice-Hall, Inc., 1964).
- Alston, Walter Emmons, The Complete Baseball Handbook (Boston: Allyn and Bacon, Inc., 1972).
- Bunn, John, Scientific Principles of Coaching (Englewood Cliffs: Prentice-Hall, Inc., 1957).
- Coombs, Jack, Baseball, Revised by Danny Litwhiler (Englewood Cliffs: Prentice-Hall, Inc., 1967).
- Dugan, Ken, How to Organize and Coach Winning Baseball (West Nyack, N.Y.: Parker Publishing Co., Inc., 1971).
- Ledbetter, Virgil, Coaching Baseball (Dubuque, Iowa: William C. Brown Publishing Co., 1964).
- Reiff, Guy G., What Research Tells the Coach About Baseball (American Association for Health, Physical Education and Recreation, 1971).
- Siedentop, Daryl and Jim Kaat, Winning Baseball: Science and Strategies (Glenview, Ill.: Scott, Foresman and Co., 1971).
- Watts, Lew, The Fine Art of Baseball (Englewood Cliffs: Prentice-Hall, Inc., 1964).

B. PERIODICALS

- Bresnahan, G. T., "A Study of the Movement Pattern in Starting a Race From a Crouched Position," Research Quarterly Supplement, 5:5-11, March, 1934.
- Cureton, T. K., "Mechanics of Track Racing Start," Scholastic Coach, 5:28-31, January, 1935.
- Edwards, Donald K., and Franklin Lindeburg, "A Comparison of the Jab-Step vs. the Cross-Over Step in Running a Short Distance," Research Quarterly, 40:284-87, May, 1959.

Henry, Franklin M., and Malcolm Stock, "Force Character of Sprint Start," Research Quarterly, 23:301-06, October, 1952.

White, R. A., "Effects of Hip Elevation on Starting Time in the Sprint," Research Quarterly Supplement, 6:128-33, October, 1935.

C. UNPUBLISHED MATERIALS

Case, George, "The Running Game," Mimeographed Sheet, National Collegiate Baseball Coaches Association.

Dickerson, A. D., "Relationship Between Foot Spacing, Starting Time, Speed in Sprinting and Physical Measurements" (Master's Thesis, University of Iowa, 1938).

Keller, Buzzy, Director, Kansas City Royals Baseball Academy, Sarasota, Florida, Letter of Correspondence, February 25, 1974.

APPENDICES

APPENDIX A
DIAGRAM OF CIRCUIT

APPENDIX B

TABLE OF RANDOMIZED SEQUENCES OF STARTS AND RED LIGHTS FOR GROUP I

Trial	I	II	III	IV	V	VI	VII	VIII	IX	X
1.	S ₂	C ₁	Red	Red	SL ₂	Red	SL ₁	J ₃	S ₁	J ₁
2.	Red	Red	Red	C ₁	Red	S ₃	S ₁	S ₂	S ₃	S ₁
3.	SL ₂	S ₁	C ₃	S ₁	SL ₃	C ₃	Red	Red	Red	SL ₂
4.	SL ₃	C ₃	Red	S ₂	Red	Red	C ₃	SL ₁	SL ₁	S ₂
5.	C ₁	S ₃	SL ₁	SL ₂	Red	SL ₃	C ₁	C ₁	SL ₃	C ₂
6.	J ₃	C ₂	C ₁	Red	Red	SL ₂	S ₃	Red	C ₁	SL ₃
7.	S ₃	J ₁	SL ₃	Red	J ₂	Red	J ₂	J ₂	SL ₂	S ₃
8.	Red	Red	J ₂	S ₃	C ₁	Red	Red	Red	J ₁	Red
9.	Red	SL ₁	C ₂	Red	J ₁	C ₁	J ₁	Red	J ₃	J ₃
10.	Red	SL ₃	SL ₂	SL ₃	C ₃	C ₂	S ₂	S ₃	Red	C ₁
11.	J ₂	J ₃	J ₁	Red	S ₃	J ₂	J ₃	S ₁	Red	J ₂
12.	Red	Red	Red	C ₃	S ₂	Red	Red	SL ₃	C ₂	Red
13.	SL ₁	Red	S ₁	J ₂	J ₁	Red	Red	Red	Red	Red
14.	C ₃	Red	Red	C ₂	Red	SL ₁	Red	J ₁	Red	Red
15.	J ₁	SL ₂	J ₃	J ₃	SL ₁	J ₃	SL ₃	C ₃	C ₃	C ₃
16.	Red	S ₂	S ₂	Red	C ₂	S ₂	C ₂	SL ₂	Red	Red
17.	S ₁	J ₂	S ₃	J ₁	Red	S ₁	SL ₂	C ₂	S ₂	SL ₁
18.	C ₂	Red	Red	SL ₁	J ₃	J ₁	Red	Red	J ₂	Red

C = Cross-Over

S = Sprinters Start From Base

SL = Sprint With Lead

J = Jab-Step

I, II, etc. = Subjects

Red = Red Light Sequences

APPENDIX C

TABLE OF RANDOMIZED SEQUENCES OF STARTS AND RED LIGHTS FOR GROUP II

Trial	I	II	III	IV	V	VI	VII	VIII	IX	X
1.	Red	Red	C ₃	J ₁	J ₂	J ₂	Red	C ₁	Red	Red
2.	C ₂	Red	S ₂	J ₃	S ₃	C ₃	SL ₃	SL ₂	C ₂	SL ₁
3.	J ₁	C ₁	SL ₃	Red	Red	Red	C ₃	Red	J ₃	J ₃
4.	Red	Red	Red	S ₂	Red	S ₁	Red	S ₁	S ₁	C ₃
5.	J ₃	C ₃	S ₁	S ₁	S ₁	Red	J ₁	J ₁	J ₁	Red
6.	Red	Red	J ₂	Red	J ₃	S ₃	S ₁	Red	SL ₃	J ₂
7.	Red	J ₁	J ₁	Red	Red	S ₂	Red	Red	Red	SL ₃
8.	S ₃	SL ₁	J ₃	Red	Red	C ₁	S ₂	SL ₁	SL ₂	S ₃
9.	S ₂	C ₂	Red	J ₂	C ₂	SL ₃	J ₂	C ₂	Red	SL ₂
10.	S ₁	J ₃	Red	S ₃	S ₂	J ₃	SL ₁	SL ₃	Red	Red
11.	Red	SL ₃	S ₃	SL ₁	Red	Red	Red	C ₃	C ₁	Red
12.	SL ₂	S ₁	Red	SL ₃	C ₁	SL ₂	C ₁	Red	S ₂	C ₁
13.	Red	SL ₂	SL ₁	C ₁	C ₃	Red	Red	J ₂	Red	C ₂
14.	C ₁	Red	Red	Red	SL ₁	Red	J ₃	S ₃	C ₃	S ₁
15.	SL ₃	S ₃	C ₂	SL ₃	SL ₃	C ₂	C ₂	Red	S ₃	Red
16.	J ₂	J ₂	C ₁	Red	Red	Red	Red	S ₂	J ₂	Red
17.	C ₃	S ₂	Red	C ₂	J ₁	SL ₁	SL ₂	Red	Red	S ₂
18.	SL ₁	Red	SL ₂	C ₃	SL ₂	J ₁	S ₃	J ₃	SL ₁	J ₁

C = Cross-Over

J = Jab-Step

S = Sprint From Base

SL = Sprint With Lead

I, II, etc. = Subjects

Red = Red Lights Sequence

APPENDIX D

TABLE OF RANDOMIZED SEQUENCES OF STARTS AND RED LIGHTS FOR GROUP III

Trial	I	II	III	IV	V	VI	VII	VIII	IX	X
1.	C ₃	J ₁	S ₂	Red	SL ₁	S ₁	C ₂	Red	Red	Red
2.	SL ₁	Red	S ₃	Red	SL ₃	SL ₁	C ₁	SL ₁	Red	C ₁
3.	C ₁	C ₁	C ₃	J ₂	Red	J ₁	Red	S ₁	Red	J ₃
4.	S ₁	SL ₃	C ₁	S ₁	J ₁	C ₃	Red	Red	SL ₃	J ₂
5.	Red	C ₃	J ₂	Red	J ₂	SL ₃	SL ₃	SL ₂	Red	Red
6.	J ₃	S ₃	J ₁	C ₃	Red	Red	S ₁	SL ₃	SL ₂	C ₃
7.	S ₃	Red	S ₁	S ₃	C ₂	Red	Red	S ₃	S ₃	C ₂
8.	Red	J ₂	SL ₁	Red	Red	S ₂	SL ₁	J ₁	Red	J ₁
9.	J ₁	SL ₁	SL ₃	SL ₃	Red	SL ₂	Red	J ₂	S ₁	S ₃
10.	SL ₃	Red	SL ₂	C ₂	S ₁	S ₃	Red	C ₁	Red	Red
11.	Red	J ₃	Red	J ₃	S ₂	Red	C ₃	Red	C ₃	Red
12.	J ₂	S ₂	Red	Red	J ₃	Red	J ₂	C ₃	C ₁	SL ₃
13.	Red	Red	Red	C ₁	Red	J ₃	J ₁	J ₃	SL ₁	S ₁
14.	S ₂	Red	C ₂	Red	S ₃	C ₁	S ₃	C ₂	J ₁	Red
15.	SL ₂	S ₁	Red	J ₁	C ₃	Red	SL ₂	Red	J ₂	SL ₃
16.	Red	SL ₂	J ₃	S ₂	SL ₂	C ₂	Red	Red	S ₂	SL ₂
17.	J ₂	Red	Red	SL ₁	Red	J ₂	S ₂	Red	C ₂	Red
18.	Red	C ₂	Red	SL ₂	C ₁	Red	J ₃	S ₂	J ₃	S ₂

C = Cross-Over

J = Jab-Step

S = Sprinters Start Base

SL = Sprinters Start With Lead

I, II, etc. = Subjects

Red = Red Light Sequences

APPENDIX E
SAMPLE DATA SHEET

NAME: _____

AGE: YEARS _____ MONTHS _____

GROUP: _____

SUBJECT NUMBER: _____

CLASSIFICATION: _____

	Cross-Over	P0	Jab-Step	P0	Sprint From Base	P0	Sprint With 3 ft. Lead	P0
Trial 1								
Trial 2								
Trial 3								
Mean								

P0 = Pick Off

APPENDIX F

TABLE OF RAW TEST-RETEST DATA FOR CROSS-OVER STEP-START

Subjects	X	Y
D.L.	3.79	3.82
A.H.	4.05	4.05
J.N.	3.93	3.94
R.R.	3.87	3.84
T.P.	3.73	3.80

X = Test
Y = Retest

APPENDIX G

TABLE OF RAW TEST-RETEST DATA FOR JAB-STEP START

Subjects	X	Y
D.L.	3.81	3.80
A.H.	4.09	4.11
J.N.	4.02	4.00
R.R.	3.82	3.87
T.P.	3.78	3.79

X = Test
Y = Retest

APPENDIX H

TABLE OF RAW TEST-RETEST DATA FOR SPRINTERS START FROM THE BASE

Subjects	X	Y
D.L.	3.92	3.94
A.H.	4.09	4.08
J.N.	4.16	4.13
R.R.	4.03	4.02
T.P.	3.98	3.98

X = Test
Y = Retest

APPENDIX I

TABLE OF RAW TEST-RETEST DATA FOR SPRINTERS START WITH A LEAD

Subjects	X	Y
D.L.	3.85	3.85
A.H.	4.07	4.05
J.N.	4.07	4.09
R.R.	3.90	3.92
T.P.	3.82	3.82

X = Test
Y = Retest

APPENDIX J

TABLE OF MEAN TIMES FOR SUBJECTS

Subject	Cross-Over	Jab-Step	Sprint Base	Sprint Lead
1.	3.93	4.02	4.16	4.07
2.	4.44	4.44	4.56	4.56
3.	4.01	4.07	4.32	4.19
4.	3.94	3.86	4.06	3.93
5.	4.70	4.49	4.68	4.61
6.	3.85	3.98	3.96	3.84
7.	3.97	4.05	4.21	4.17
8.	4.32	4.47	4.42	4.30
9.	4.54	4.70	4.50	4.53
10.	4.12	4.22	4.16	4.12
11.	4.05	4.09	4.09	4.07
12.	4.06	4.02	4.27	4.26
13.	3.91	3.93	4.02	3.99
14.	4.05	4.01	4.02	4.06
15.	4.21	4.20	4.30	4.40
16.	3.87	3.85	4.07	3.95
17.	3.79	3.81	3.92	3.85
18.	4.04	4.07	4.07	4.08
19.	3.93	3.95	4.03	3.89
20.	4.10	4.27	4.22	4.12
21.	3.67	3.64	3.79	3.80
22.	4.08	3.87	3.93	3.89
23.	3.78	3.78	3.98	3.96
24.	3.73	3.78	3.98	3.82
25.	3.87	3.77	4.00	3.97
26.	3.65	3.68	3.96	3.83
27.	3.84	3.88	4.00	3.91
28.	3.87	3.82	4.03	3.90
29.	4.07	4.02	4.05	3.72
30.	3.96	3.95	4.07	3.93