CINEMATOGRAPHICAL COMPARISON OF THE STANDING AND THE CROUCH SPRINT STARTS WHEN USED BY MALE HURDLERS.

By

David Ainley

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Arts(Physical Education)

Division of Graduate Studies and Research,
Faculty of Education,
McGill University,
Montreal, Quebec.

March 1976

TO MY MOTHER AND FATHER

ABSTRACT

This study investigated the comparitive merits of the standing sprint start and the crouch sprint start,when used by male hurdle competitors.

Data was collected by means of cinematography,using two synchronised Locam motion picture cameras to film five provincial hurdlers performing two trial 27.0 metre runs from each of the two starting positions.

When subjected to ANOVAR and post hoc techniques, the mean performance scores indicated that there was a significant difference at the .05 level of confidence, in favour of the crouch start over the standing start, in the amount of time taken to clear the starting blocks. There was no other significant difference between the two types of start, for any other time measure recorded, up to and including 27.0 metres.

Division of Graduate Studies and Research,
Faculty of Education,
McGill University,
Montreal, Quebec.

RESUME

Cette etude examine la valeur relative des positions de départ du 'sprint', soit le départ debout et le départ accroupi, que les coureurs prennent dans les courses d'obstacles (catégorie hommes).

Des donnes furent recueillies au moyen de la cinématographie : deux cameras de cinéma synchronisées Locam filmèrent cinq coureurs de haies de la province de Québec lors de deux courses d'essai de 27 mètres ou 2 figurait chacune des deux positions de départ.

La moyenne des resultats obtenus, lorsque soumise aux techniques ANCVAR et post hoc a un niveau de confiance de .05, indiquait une différence significative en faveur du départ accroupi quant au temps mis a quitter la ligne de départ.

Il n'y eut pas de différence significative entre les deux types de départ pour tout autre mesure enregistrée jusq'a 27 mètre inclus.

Division Des Etudes Graduées
Et De La Recherche,
Faculté de L'Education,
Université Mc Gill,
Montréal, Québec.

ACKNOWLEDGEMENTS

My thanks are due to several people for various types of assistance and encouragement, which made the completion of this study possible.

I am grateful to my wife for her understanding and most valuable encouragement, particularly during the final stages of completion, when considerable amounts of time, normally devoted to family activities were claimed by the demands of this study, from the leisure time left after meeting the demands of a High School teaching position.

My thanks are due to Mr. Bradley and Mr. Henshaw of the Industrial Arts Department at Monklands High School, for their many adjustments to pieces of equipment vital to the study.

To Mr. Dedic of the Department of Mechanical Engineering Mc Gill University, for his work on the electronic apparatus used in the investigation.

To Mr. R. Oulton, Principal, Riverdale High School, for allowing the filming to be done on the all weather track at the school.

To Dr. J. Skinner, Department of Physical Education, University of Montreal, for the use of the Vanguard Motion Analyser.

To the Mc Gill University Department of Physical Education for their help.

To Dr. D.Q. Marisi for his assistance with the statistical content of the study. As Dr. Marisi remarked in a mellow moment, a piece of research is only a chip on top of a mountain.

Fortunately, my advisor, Dr. M.C. Greenisen is a first class mountaineer. Because of his interest, patience, friendship and professional guidance, it was possible for me to deposit my " chip on top of the mountain".

Some climb.

D.A.

# LIST OF ABBREVIATIONS.

| | |
|---|---|
| $S$ | Displacement. |
| $\Delta S$ | Displacement during a timed interval. |
| $t$ | Time from the start. |
| $\Delta t$ | Duration of a timed interval. |
| $V_t$ | Velocity at the end of each timed interval. |
| $\overline{V}$ | Average velocity during the timed interval. |
| $V_o$ | Vt of the previous timed interval. |
| $a$ | Acceleration. |
| $S_{xo}$ | Initial horizontal displacement. |
| $S_{xi1}$ | Horizontal displacement to the end of the first interval. |
| $S_{xi2}$ | Horizontal displacement to the end of the second interval. |
| $t_o$ | Initial time. |
| $t_{i1}$ | Change in time across the first interval. |
| $t_{i2}$ | Change in time across the second interval. |

TABLE OF CONTENTS

## LIST OF TABLES

TABLE | PAGE

# LIST OF FIGURES

# CHAPTER I

# INTRODUCTION

## 1.1 Nature and Scope of the Problem.

A photo of the men's 100 metre sprint final at the first Olympiad in 1896 shows that both the crouch and the standing starts were used.(31) By 1906, even runners in the 400 metre race, with one exception, were using the crouch start. Since then, until very recently, the crouch start has been used in all sprint and hurdle races of any importance.

Interest in the standing start was rekindled when Paul Nash, a South African sprinter, recorded a 10.1sec time whilst using the standing start. Two Junior Interscholastic hurdlers were able to improve their 50 metre times by 0.4sec and 0.2sec at their first exposure to the standing start technique.

Many sprint and hurdle races are won by a small margin and it is not unusual for a photo of the finish to be consulted before a winner can be declared. Therefore, minute advantages assume great importance in these athletic events.

When the crouch start is used, the average sized athlete will have his front foot between 14" and 18" behind the starting line. This is necessary in order to leave space to place the hands on the track, without them being on or over the starting line.

With the standing start, since the hands are not in contact with the ground, the athlete can have his front foot just 2" behind the starting line. Therefore, before the gun is fired to start the race, the athlete using the standing start has an advantage of between 12" and 16" over opponents using the crouch start. This advantage is doubly useful in hurdle races. Only tall athletes are able to reach the first hurdle of the mens 110 metre hurdle race in seven strides from the crouch starting position, without undue stretching and loss of stride cadence resulting in loss of velocity. It is possible that block placement of the standing start, because the front foot is so much nearer to the starting line, will allow more athletes to reach the first hurdle in seven strides.

A right dominant sprinter or hurdler will have the right leg as the rear leg in the sprint start. However, the right dominant hurdler uses the left leg as the leading leg in the hurdling action. If he is to do both these things, the seven stride approach to the first hurdle must be used. When the eight stride approach is used, hurdlers reverse the legs in the sprint starting position, rather than change the leading leg in the hurdling action.

Ward(30) in a study of the 100 yard sprint race, found that the front leg in the crouch start position contributed 72.03% of the total horizontal impulse and 59.71% when the standing start was used. This data indicates that it

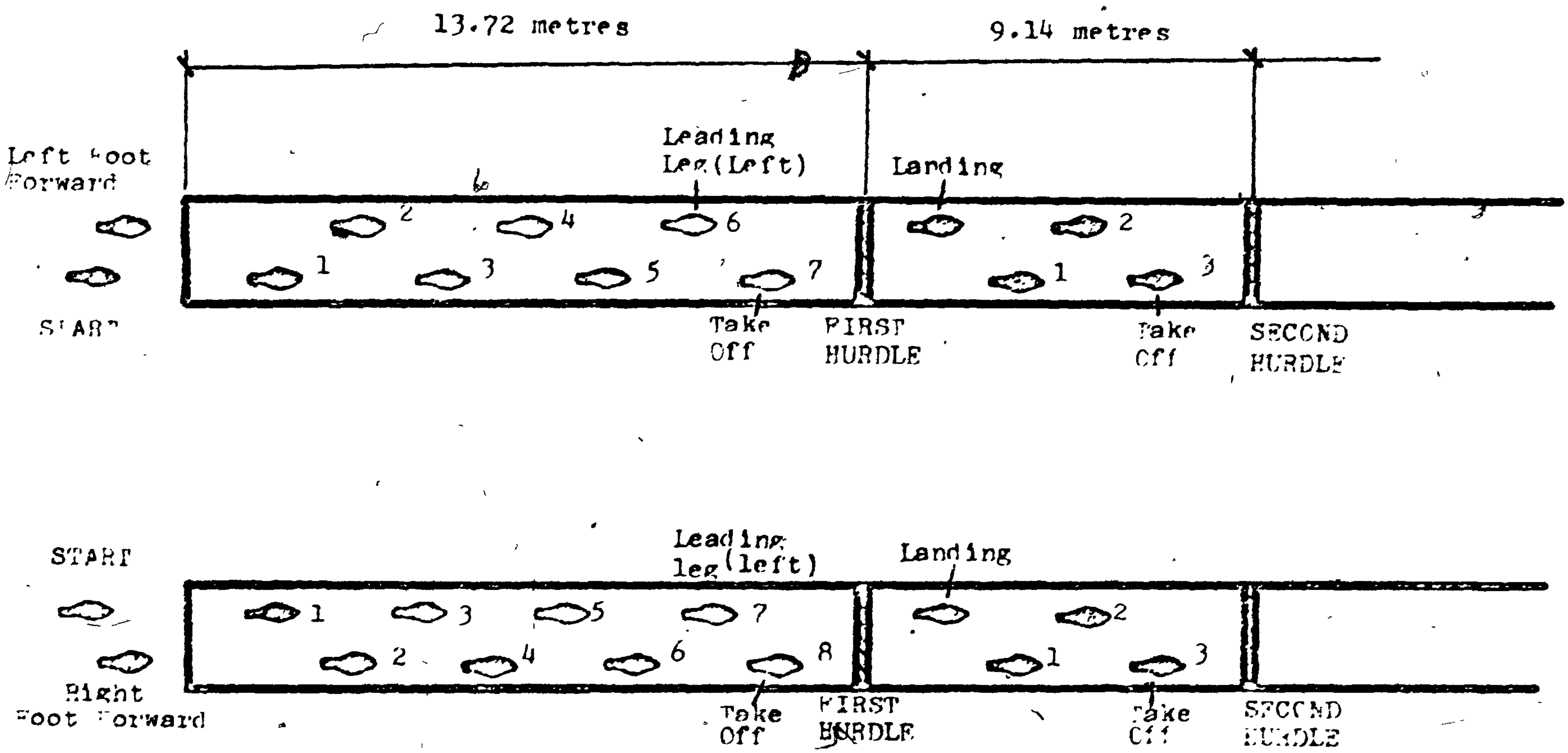


Figure 1. Seven and Eight Stride Approach Patterns to the First Hurdle for a Right Dominant Hurdler.

is better for the hurdler if he is able to have the foot of his choice forward in the starting position, so as to be able to achieve maximum force application against the starting blocks.

According to Decker and Fey (7) perfect trunk position for the sprint start lies between the body positions attained in the 'set' phase of the standing and the crouch start positions. The crouch start requires the athlete to raise his trunk, whilst the standing start requires the trunk to be lowered. Neither start can provide the perfect body position. At this time there is no scientific evidence available as to which method is better for the 110 metre hurdler.

1.2 Statement of the Problem.

The purpose of this study was to determine whether the standing start, when compared to the crouch start, allowed a superior performance over the initial 27 metres of a 110 metre high hurdle course.

The study compared the amount of time taken to clear the starting blocks, after the subject made his initial response to the starting gun, for each type of start. Times were taken at the displacement points of 1.5, 9.0, 13.72 (first hurdle), 18.0, 22.86 (second hurdle), and 27.0 metres.

Null Hypothesis:

That there would be no significant difference in the time taken to reach 27 metres in the men's 110 metre high hurdle race when the standing and the crouch start are used. Acceptance or rejection of this problem will be at the .05 level of confidence.

Sub-Problems tested

1. That there would be no significant difference in the times taken to clear the starting blocks, once the first response to the starting gun has been made, whether the standing or the crouch start is used.
2. There would be no significant difference in the time taken to reach the displacement points of 1.5, 9.0, 13.72, 18.0 and 22.86 metres whether the standing or the crouch start is used.

1.3 Rationale

Since 1933, when Walker & Hayden (29) compared the starting times of runners using holes in the track, with the starting times of runners using starting blocks, many aspects of sprint starting, including variations of block placement(6,8,10,14,19,22, 25), have been researched most thoroughly. The start is just as crucial in the 110 metres hurdle race as it is in the 100 metres sprint race. Nevertheless, this author has not been able to find any research dealing with the possibility that one type of start may be superior to the others for hurdling.

The close placement of the front block to the starting line in the standing start may have advantages for the 110 metre hurdler. Because of the great amount of mechanical skill required for effective and consistent hurdling, skilled athletes were used as subjects. The valid data yielded by studying this problem will contribute towards helping athletes and coaches decide if the standing start is, or is not, a worthwhile alternative to the crouch start for 110 metre hurdlers.

A need exsists to expand knowledge in this area by means of scientific research.

1.4 Delimitations of the Study.

1.41 It was decided that the subjects for this investigation should be hurdlers of provincial calibre, who compete regularly in the Montreal area. Because of the very limited number of such subjects, the number of participants was five.

1.42 Reaction time was not included in the study, since Ward (30) found only a 0.002 sec. difference between standing and crouch start reaction time.

1.5 Limitations of the Study.

1.51 The testing was not done in front of a crowd, thus some of the motivation associated with an important race, to which these subjects are accustomed, was missing. However, other hurdlers were watching and it is hoped that this proved to be a compensating factor.

1.52 The study was limited to the first 27.0 metres of the race, since this was the greatest distance which could be filmed from close enough to provide a picture large enough for analysis.

1.6 Definition of Terms

Standing Start: A start during which the hands of the athlete are not in contact with the ground. The recommended block placement for the start is to have the front block 2" behind the starting line and the rear block 20" to 24" behind the front block.

Crouch Start: A start during which the hands of the athlete are in contact with the ground. There are three main types of crouch start, each with different block placement to the other two (6). They are the Bunch, Medium and Elongated starts and block placement is summarised in Table I.

TABLE I

Recommended Starting Block Placement for the Three Types of Crouch Start

| | Type of Start | Distance behind the starting line Front Block | Rear Block |
|---|---|---|---|
| 5'8" athlete | Bunch | 18" | 28" |
| | Medium | 15" | 33" |
| | Elongated | 11" | 37" |
| 6'1" athlete | Bunch | 21" | 32" |
| | Medium | 16" | 37" |
| | Elongated | 14" | 42" |

Mens 110 Metre Hurdle Race:

Distance to the first hurdle is 13.72 metres.

There are ten hurdles 9.14 metres apart.

Last hurdle to the finishing line is 14.02 metres

Height of the hurdles is 1.029 metres(3'6")

Reaction Time: within the context of sprinting this may be defined as the amount of elapsed time between the stimulus (firing of the starting gun), and the first response of the athlete.

Clearing the Starting Blocks: The amount of time between the firing of the gun and the athletes front foot leaving the front starting block. For the purposes of this study, clearing the blocks will be the amount of time between the subjects first response to the starting gun($t_0$) and the front foot leaving the starting block.

Commands at the Start of a Race: 1."on your marks."

2. "Set"

3. Gun is fired.

Holding Period: The period of time for which it is customary to keep athletes in the set position prior to the firing of the starting gun. This is recommended to be 1.4 secs to 1.6 secs (28).

False Start: If an athlete moves in the set position prior to the firing of the starting gun.

<u>Disqualification</u>: An athlete is disqualified from a race after being charged with two false starts.

<u>Leading Leg of the Hurdler</u>: The first leg of the athlete to cross the hurdle and the leg on which the athlete lands after clearing each hurdle.

<u>Trailing Leg of the Hurdler</u>: The second leg of the athlete to clear the hurdle.

<u>Take-off Leg of the Hurdler</u>: The leg which is last to leave the ground before each hurdle is cleared. For a hurdler, the take-off leg is the same as the trailing leg.

<u>Displacement</u>: The straight line distance between two points in a given direction.

<u>Velocity</u>: The time rate of change of displacement.

<u>Acceleration</u>: The positive time rate of change of velocity.

<u>Deceleration</u>: The negative time rate of change of velocity.

<u>Initial Time</u>: The time at which the subjects first response to the starting gun occurs.

# CHAPTER II

## REVIEW OF LITERATURE

### 2.1 The most effective Crouch Sprint Start

In 1934, Dickinson(6) concluded that the bunch start was the most effective type of crouch start. The conclusion was based on times taken for clearing the starting blocks and reaching a point 2½ yards beyond the starting line.

Kistler(14), also in 1934, studied the total force applied to the starting blocks for the bunch, medium and elongated sprint starting positions. His results showed that a force of 346 pounds of force was applied to the blocks in the bunch position, 386 pounds of force in the medium start position and 404 pounds of force in the elongated starting position. Since the elongated start allowed the greatest amount of force to be developed against the starting blocks, it was concluded that this was the most effective starting position. However, Henry(8) in 1952 shed some light on this apparent contradiction. He found that subjects were able to clear the starting blocks in the least amount of time when the bunch starting position was used but the subjects had less velocity than when the other starting positions were used, so that the initial advantage was quickly lost. With the elongated starting position, the subjects left the starting blocks after a longer period of time but with the greatest velocity. The medium start however, a compromise between the two previously mentioned positions, gave the best and most consistent times to 10 and 50 yards.

Stock(25) in 1962, supported the findings of Henry. The medium start was found to be superior to the other positions to 20 and 50 yards. It was determined that with the elongated start the sacrifice of time in the blocks for power, was too much to make up in order to match the performance of the medium start.

Menely and Rosemier(19) considered a variation of the medium start and referred to it as the hyperextended position. Block spacing was the same as for the medium start except that the front block was moved as close to the starting line as was possible. This had the effect of forcing the hips into a higher position. Using 30 inexperienced subjects, a significant difference was found in favour of the hyperextended position to 10 and 30 yards as compared to the other types of crouch start. Stock (20) referred to this type of start as the medium hip high start he also found it to be significantly superior to the bunch and elongated starts to 20 and 50 yards. The same held true for the medium start.

Gagnon (10) found that when the centre of gravity of the body was moved closer to the starting line, faster times were achieved by 4 University sprinters. The blocks placed closer to the starting line made the start similar to the hyperextended start used in the Menely and Rosemier study(19)

It seems clear that the medium start position is superior to the bunch and elongated sprint starting positions according to modern research.

2.2 Acceleration patterns of Sprinters

In 1951, Henry and Trafton(14) studied the velocity curve of sprint runners. Using 25 P.E. Majors as subjects, in a group which included no experienced track men, they found that 90% of the acceleration took place in the first 15 yards and 95% in the first 22 yards.

Sills and Pennybaker(24) used 9 University sprinters in their 1956 study. Times were recorded at 5 yard intervals to a distance of 35 yards beyond the starting line. Maximum velocity was achieved by 5 subjects between 15-20 yards, 3 between 20-25 yards and 1 between 30-35 yards.

Sigerseth and Grinaker (22) investigated the influence of foot spacing in the starting position on velocity in sprint running. Using 26 P.E.Majors, including 4 sprinters as subjects, times were taken at 10, 20, 30, 40 and 50 yards for the bunch, medium and elongated starting positions. The medium starting position provided superior times at 10, 20 and 50 yards.

Best and Partridge(1) conducted tests on the 1926 Olympic sprint champion and found that maximum velocity was achieved between 45 and 50 yards.

Many of the studies investigating the acceleration patterns of sprinters used subjects who were not sprinters. The literature shows that the first class sprinter continues to accelerate to distances in excess of P.E.Majors. It is clear that there is individual variation in the paricular point where maximum velocity is achieved. It is also evident that at least 90% of the acceleration comes in the first 30 yards.

This author has not been able to trace any literature concerning research into the velocity and acceleration patterns of hurdlers.

2.3 Reaction Time and Sprinting ability

Most people are of the opinion that top class sprinters have very fast reaction times and that this is a factor in their success as sprinters. Henry(8) showed that, contrary to popular belief, the correlation between individual reaction time and a 50 yard sprint was 0.18. Reaction time was taken to be the elapsed time between the firing of the starting gun and the first response of the runner. It was also found that changes in starting block position did not influence reaction time. Scott(21) found a correlation of 0.28 between the mean performance score for 60 finger presses for a given stimulus and mean performance in two dashes of 50 yards. Henry and Trafton(9) found that reaction time and 50 yard sprint time gave a 0.14 correlation and concluded that individual differences in reaction time can be neglected, except for very short distances, perhaps 10 or 15 yards at the most.

Lacy(15) used P.E.Majors and College trackmen as subjects to investigate the relationship between reaction time and running speed. Reaction time was taken as being the speed of response of each hand and foot to the sound of a buzzer. Starting time was taken to be the amount of time needed to clear the starting blocks after the gun shot. Results showed that no significant relationship existed between starting time or reaction time for either the P.E.Majors or the College trackmen.

Payne and Blader(20) reported a mean reaction time of 0.09 sec for sprinters reaction time to the starting gun in their study and concluded that such fast times were not total reaction times but rather 'pre-motor periods' of total reaction time.

Toomasulu (26) agreed with Henry and Trafton(9) that reaction time and speed of movement are often unrelated. Six sprinters running a competitive 100 metre race showed reaction times ranging from 0.13sec to 0.24 sec whilst being very close in sprinting ability. Toomasulu thought that total reaction times faster than 0.100 sec to be impossible as the maximum velocity of the afferent and efferent nerve impulses precluded it.

Ward(30) found that the mean reaction time in the standing start was 0.071sec and 0.069sec for the crouch start. He agreed with Toomasulu and Payne and Blader that such a short time does not represent true reaction time.

No study claimed that reaction time was an important contributory factor in sprinting performance.

## 2.4 The effects of a Warm-Up

Hipple(11) found that a preliminary warm up did not help a group of 28 Junior High School boys to record faster times when sprinting 50 yards. They were timed on five separate sprints, with the first sprint being regarded as a warm-up for the second sprint, and so on. The results showed that times did not vary until the fourth and fifth attempt, when they slowed down a little, no doubt due to fatigue.

Mathews and Snyder (16) tested quarter milers after a controlled warm-up and with no warm-up at all. The controlled warm-up consisted of a quarter mile jog, six push-ups and 3 ten-yard sprints. The warm-up did not significantly improve performance.

McGavin (18) investigated the effect created by warm-ups of varying intensity on speed of leg movement. He found that a warm-up was beneficial to this activity. Generally, high intensity warm-ups were better than moderate warm-ups for activities utilising leg movement.

It is worth noting that no study claimed that running performance was worse because of a warm-up. Some studies did not use top class athletes and it is quite possible that the less intense efforts of these subjects would be less affected by the lack of a warm-up than would the explosive effort of a top class sprinter or hurdler.

2.5 Sprint Repetitions and Fatigue.

F. Jerome (13) used 24 trained sprinters as subjects to investigate the problem of deterioration of performance caused by fatigue due to sprinting 40 yards six times in 20 minutes. The times for the six sprints showed no significant difference at the 0.10 level of confidence. An analysis was performed to find out where in the order of the six runs, the greatest number of fastest times and slowest times occurred. Start number three had the greatest number of both fast and slow times. No patterns of slow times in trial runs 4,5 and 6 because of fatigue, or faster times due to increasing familiarity with the task was discovered.

This would seem to indicate that trained subjects can safely undertake up to six repetitions of sprinting to 40 yards during one session without the factors of fatigue or familiarity prejudicing performance.

2.6 The Standing Start

Major John Short(23) devised the modern standing start for Paul Nash, a South African world class sprinter. Major Short gathered some interesting information at a National Junior Clinic in South Africa in 1970. In his report it is emphasised that the findings were made without the aid of electronic timing devices and therefore should not be regarded as conclusive. Using only a standard starting block to support the front foot, 26 out of 30 sprinters immediately improved their 50 metre sprint times by 0.2sec or 0.3sec. The runners spent longer in the starting blocks than they did when the crouch start was used.

Some woman hurdlers found that the standing start allowed them to reach the first hurdle in 7 strides instead of the 8 strides they had been using with the crouch start. The standing start also gave a 0.2sec or 0.3sec faster time to the first hurdle.

Bill Bowerman(2) the U.S.A. Olympic track coach stated that an Olympic quarter miler and an N.C.A.A. hurdler both covered the 40 yard dash 0.2 sec faster when they used the standing start. Details of the testing procedure were not given. Surprisingly, it was added that the athletes reverted to the crouch start in competition, since they felt selfconscious using the standing start in front of a crowd, when all the other competitors were down in the crouch start position.

A doctoral thesis by Robert F. May Jr., (18) at Louisiana State University in 1972, compared the standing and the crouch starting positions in response time and velocity over the initial 15 yards of a race. The subjects for this study were 22 males selected from a required physical education class in weight training and isometrics. Students with sprinting experience were disqualified from the study. A thorough warm-up was done prior to the testing. A cord attached to the subjects' shorts at one end and a Dekon timer at the other end disconnected when the subjects had run the required distance and the time to the nearest 1/100th sec was recorded. Results showed a significant difference at the .01 level of confidence in favour of the crouch start over the standing start in response time (block clearance). There was no significant difference in velocity over the 15 yard course between trials from the two starting positions. The author recommended that studies be done with competitive sprinters and hurdlers over greater distances.

J. Trvniecki (27) investigated the effectiveness of the bunch start and the standing start on performance in the first 10 yards of the race. His nine subjects, who had no track experience, averaged 0.3 second faster when standing start was used.

Desipres (5) used cinematography and electromyography to study standing and crouch sprint performance during the first second of the race. Ten male and seven female subjects with sprinting experience were used. The crouch start gave significantly faster times at the .01 level of confidence.

P. E. Ward's (30)doctoral thesis is the most detailed comparison of the standing and crouch sprint starts which this author has been able to locate. His subjects were 11 University track men, whose time for the 100 yard sprint ranged from 9.3 seconds to 10.0 seconds. Subjects were taught and practiced the standing start for an eight week period prior to testing. At testing, two trials over the 100 yard course were taken from the standing start position on one day, and two trials from the crouch start position the next day. Times were recorded by means of photo transducers placed at ten yard intervals throughout the 100 yard run on indoor tartan track at Indiana University. The forces generated in the starting action were recorded on a mechanism attached to the starting blocks.

The findings showed that the mean times were faster at each ten yard interval of the course when the standing start was used. Each sprinter had his own acceleration pattern with maximum velocity being reached between 40 and 70 yards after the start. Subjects were able to clear the blocks faster with the crouch start( 0.41 sec) than with the standing start(0.49sec). Reaction time for the crouch start (0.069 sec) was fractionally faster than for the standing start (0.071 sec).

There was a more equal distribution of forces when the standing start was used with 59.71% coming form the front leg and 40.49% from the rear leg. The crouch start showed 72.03% coming from the front leg and 27.97% from the rear leg. The standing start allowed a larger mean horizontal impulse to be generated, resulting in subjects leaving the blocks with greater velocity than when the crouch start was used.

Ward concluded that within his study the standing start was superior to the crouch start. He recommended that studies be done investigating the performance of the standing start in hurdling events.

## 2.7 Starting Blocks for the Standing Start

Researchers (17,30) have used different starting blocks for the standing start than the ones normally employed of the crouch start. To this date, no study has been published on the merits of various types of starting block, angles at which the block faces should be set, or variations in block spacing.

The original suggestions of Major Short have been followed quite closely. The front block is placed 2" to 3" behind the starting line, to take advantage of the fact that the hands are not in contact with the ground, and the rear block, depending on the size of the athlete using it, is placed between 20" to 24" behind the front block. The face of the starting block is larger than that of the conventional blocks, so more support is provided for the foot and a more stable 'set' position is provided for the athlete. This is needed since the hands of the athlete are not in contact with the ground, as is the case with the crouch start. The rear block is inclined at 80 degrees to the horizontal and the front block at an angle of 45 degrees. Ward (30) modified the angle of the front block to 30 degrees.

Clark (4) designed a different front block for the standing start and this was used with success at the Dallas Olympic development clinic. Until research is performed in this area and one starting block arrangement is shown to be superior to the others, the choice of blocks together with angulation of the block faces will be a matter of common sense trial and error with the subjects involved.

# CHAPTER III

## METHODS AND PROCEDURES

### 3.1 Perspective of the Study

This study was undertaken to determine whether the standing sprint starting position or the crouch sprint starting position would produce better timed performances during the first 27 metres of a 110 metre hurdle course. This included clearance of the first 3'6"high hurdle at 13.72 metres and the second hurdle at 22.86 metres, as would be the case in a regular race.

Data was collected by filming each of the five subjects covering the course four times; twice from the standing start position and twice from the crouch start position.

From the processed film, it was possible to calculate the amount of time spent in clearing the starting blocks, after the subject had made his first response to the starting gun. Times were calculated for the subjects reaching the displacement points of 1.5, 9.0, 13.72, 18.0, 22.86 and 27.0 metres.

This data provided the opportunity to see whether one type of start was superior to the other, and if so, to assess where the differences began to emerge.

### 3.2 Subjects

The subjects were five male caucasian current competitive hurdlers residing in Montreal, Quebec. The age range was from 18 to 24 years and the heights ranged between 5'8" and 6'3". Two of them have represented Canada in hurdling events and another two have represented Quebec. The fifth subject is likely to achieve Quebec selection in the near future.

It was decided, that in order to collect the most valid and consistent data, a small sample of highly skilled experienced subjects was preferable to a larger sample of inexperienced subjects. The selection of subjects was additionally influenced by the high degree of mechanical skill required to hurdle effectively over the 3'6" high hurdles.

### 3.3 Subject Preparation

During the six week period prior to filming, each subject was taught the standing start. Emphasis was placed on having the trunk close to the horizontal in the 'set' position, stability in the 'set' position and driving off both feet when the starting gun was fired.

The subjects trained three or four times per week and incorporated the practice of the standing start into their regular training schedule. Practice of the crouch start was continued on a normal basis throughout this period.

### 3.4 Experimental Design

Each subject was filmed performing two trials over the 27.0 metre course, using the standing start position twice and the crouch start position twice. Each trial included clearance of the first hurdle placed at 13.72 metres and the second hurdle placed at 22.86 metres beyond the starting line. The film zone ended at 27.0 metres, but additional marker posts were placed at 32.0 metres and subjects were requested to maintain maximum velocity past them. This was done in order to prevent any needless premature deceleration by the subjects after clearing the second hurdle.

Trials of the standing and the crouch start were alternated so that no advantage or disadvantage was given to either starting position by always being filmed first or last.

| | Trial 1. | Trial 2. | Trial 3. | Trial 4. |
|---|---|---|---|---|
| Subject 1: | Stand | Crouch | Stand | Crouch |
| Subject 2: | Crouch | Stand | Crouch | Stand |
| Subject 3: | Stand | Crouch | Stand | Crouch |
| Subject 4: | Crouch | Stand | Crouch | Stand |
| Subject 5: | Stand | Crouch | Stand | Crouch |

3.5 Selection of Displacement Points for Data Collection

Data was gathered at various intervals within the 27.0 metre film zone and these are represented in Table II.

TABLE II

Intervals of Displacement and Time for Data Collection

| Interval | | |
|---|---|---|
| Starting Blocks | $S_{xo}$ | $\Delta t_o$ |
| 1.5 metres | $S_{xi1}$ | $\Delta t_{i1}$ |
| 9.0 metres | $S_{xi2}$ | $\Delta t_{i2}$ |
| 13.72 metres | $S_{xi3}$ | $\Delta t_{i3}$ |
| 18.0 metres | $S_{xi4}$ | $\Delta t_{i4}$ |
| 22.86 metres | $S_{xi5}$ | $\Delta t_{i5}$ |
| 27.0 metres | $S_{xi6}$ | $\Delta t_{i6}$ |

Clearing the starting blocks was calculated from $t_o$ to the time the front foot of the subject left the front starting block.

The change in time measured from $t_o$ at $S_{xo}$ to $S_{xi1}$ at 1.5 metres should indicate any advantage gained as a result of the different starting block placement used for the two types of starting position.

The first part of the hurdle course from $S_{x0}$ at $t_0$ to the second interval terminating at $S_{x12}$, 9.0 metres from the start was exactly like the first portion of a sprint race with no hurdle take-off preparation invlolved.

Interval three, $S_{x13}$, to 13.72 metres gave the time $\Delta t_{13}$ and indicated whether either of the two types of starting position provided a faster approach th the first hurdle.

Interval four, $S_{x14}$, to 18.0 metres, terminates almost exactly between the first hurdle at 13.72 metres and the second hurdle at 22.86 metres. This interval, considered in conjunction with the previous interval, provided data on velocity and acceleration before and after clearance of the first hurdle.

The fifth interval, $S_{x15}$, was to the second hurdle at 22.86 metres. Knowing the time $\Delta t_{15}$, enabled velocity and acceleration at the second hurdle to be known.

The final interval $S_{x16}$, to 27.0 metres gave the final time $\Delta t_{16}$ for the course. When analysed with $\Delta t_{14}$ and $\Delta t_{15}$ the effect of the second hurdle on velocity and acceleration was known, since $S_{x15}$ is placed almost exactly between $S_{x14}$ and $S_{x16}$.

With the exception of the interval $S_{x11}$, to 1.5 metres, the 27 metre course was split up into equal intervals of 9.0 metres. These intervals have the first and second hurdles at almost exactly their mid-point. Data provided knowledge of velocity and acceleration at 9.0 metre intervals and in addition showed how these factors were affected by clearance of two high hurdles placed 9.14 metres apart.

3.6 Instrumentation.

3.61 Cameras.

Filming was accomplished utilising two 16 mm. Locam high speed motion picture cameras, each equipped with a registration pin. The cameras have a variable frame rate of 10-500 frames per second, with a stability of plus or minus 1 %, or one frame, whichever is greater. Each camera is equipped with a double disc shutter, which can be adjusted from 0 degree to 160 degrees. In this study the shutters were set at 80 degrees.

The cameras were synchronized by a custom designed control centre developed by the Department of Mechanical Engineering at Mc Gill University. This control box enabled both cameras to be started or stopped individually or simultaneously from one external source. It provided one power source for both cameras and equal length leads of the same resistance to each camera. Timing light impulses from a Red Lakes Laboratory mille mite timing light generator Model 13-003 were sent via the control box to the light emitting diodes on each camera, marking the film at each 1/100 th second.

The camera taking close up pictures of the sprint start was fitted with a 25mm. lens and operated at 300 frames per second. The second camera filming the whole 27.0 metre course was equipped with a 10mm. lens and operated at 150 frames per second.

The film used in the cameras was Kodak 4XN 434 black and white reversal film, in 400 foot rolls, on balanced spools.

Light conditions were checked before each run with a Asahi Pentax Spotmeter($1^{o}$ - $21^{o}$ ) and throughout the one session of filming, stops of f 1.- and f 2.0 respectively were used.

3.02 Starting Blocks

For the standing start, the front block was the type designed by Bob Clarke(4) and used at the Olympic Developement clinic in Dallas. The front foot block was used in conjunction with a Martins Cantabrian Crystal Palace starting block as illustrated in Figure 2. An extended wooden face was bolted to each of the original blocks in order to increase the surface area supporting the rear foot to 10" by 4". The angle of the face of this block could be varied, and during the practice period, 80 degrees to the horizontal was found to be best. This angle was used for the testing session. The front block was placed 2" behind the starting line and the rear block was positioned between 20" and 24" behind the

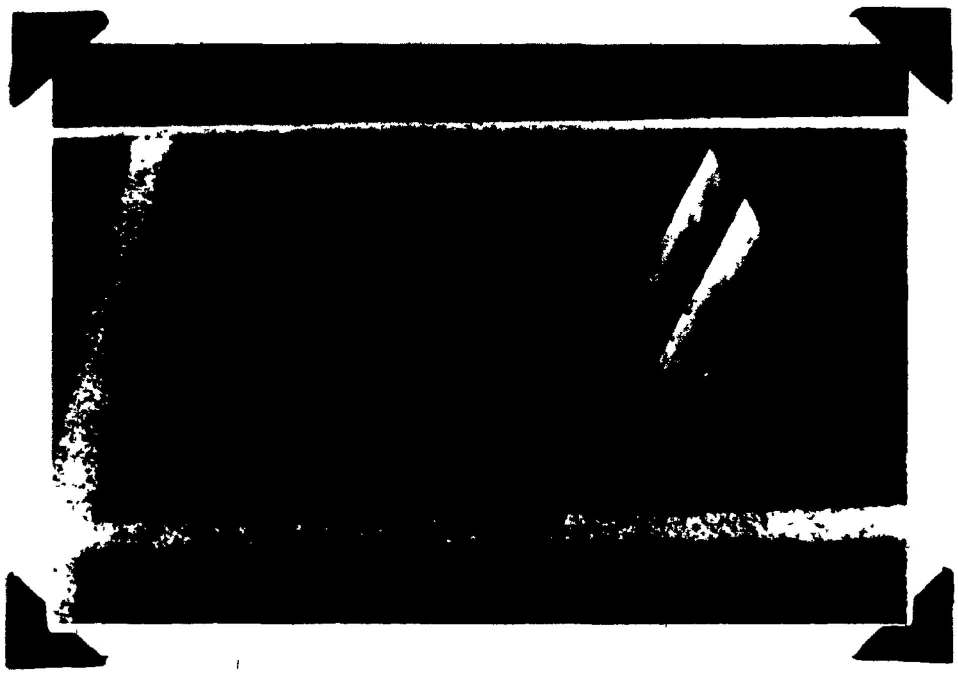

Figure 2 Special Front Block for the Standing Start used in conjunction with the Martins Cantabrian Crystal Palace Block.

front block, depending on the size of the subject.

A regular Arrett block was used for the crouch sprint start. Subjects used a medium start, and block placement varied from between 14" to 17 " behind the starting line for the front block and 33" to 37 " for the rear block. The block arrangement is illustrated in Figure 3.

3.63 The Track.

The filming was done outdoors on an all weather track at Riverdale High School, Pierrefonds, near Montreal, Quebec. Marker posts were placed at each side of the lane being used for the testing. When a subject, viewed from the rear camera filming the whole course, appeared to be between a pair of marker posts, he was actually at one of the chosen displacement points in the 27 metre course. This arrangement is illustrated in figures 4,5 and 6. Two additional posts were placed at 32 metres, so that the subjects would maintain maximum effort beyond the 27 metre film zone, thus avoiding any needless deceleration. The marker posts were painted black and white so that they would be easily visible on the processed film.

3.7 Experimental Protocol.

The hurdles, marker posts and cameras were all in position before the subjects arrived. The cameras were loaded with film and set to the prevailing light conditions. Light was checked prior to each run, but fortunately remained constant throughtout the session.

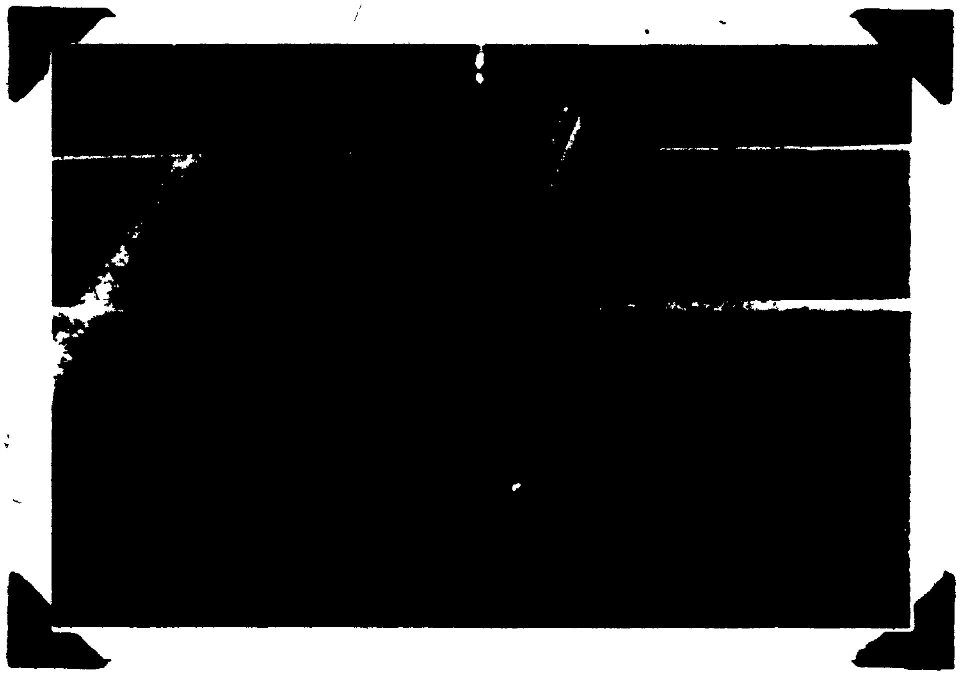

Figure 3 The Starting Block Placements for the Standing and the Crouch Sprint Starts.

Figure 4  A Practice Run with the Marker Posts in position.

Figure 5 Marker Posts as seen from behind the Rear Camera.

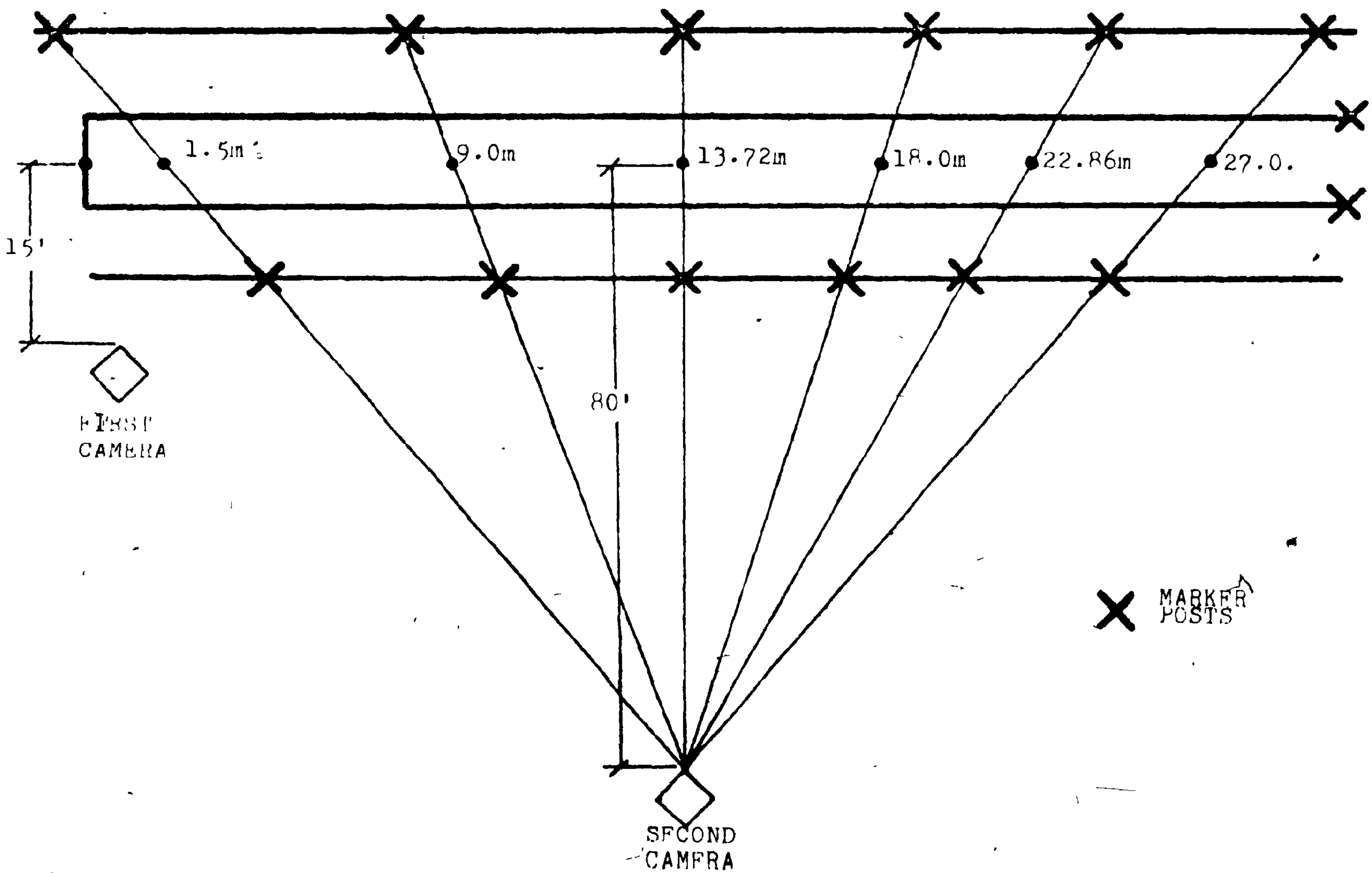


Figure 6 A diagram of the Track Lay-Out.

The front camera was placed at 15' at the side of the starting line as shown in figure 5 and set at the rate of 300 frames per second. The rear camera was placed 80' back from the first hurdle and set at 150 frames per second. Both cameras were attached to a mille mite timing light generator, in order to put a mark on the film at every 1/100 th second. A plumb line was used to make sure that the cameras were correctly placed and a spirit level confirmed the horizontal postioning of the lens. To determine distance references, a metre stick was placed in a horizontal position on the base of the centre marker post.

A black square patch of side 2" was secured to the shorts of each subject at the iliac crest to serve as reference point as he passed between each pair of marker posts.

Each subject warmed up as for regular competition before his trials were filmed. An HMGF Model 22, 6 mm. West German starting gun was used for starting purposes. A five minute period of time was allowed between trials. During this rest period for the subject, a light reading was taken, equipment checked and the starting blocks adjusted for the next trial.

3.8 <u>Data Analysis</u>.

3.81 <u>Cinematographical Analysis of the Film</u>.

The processed film was analysed with the aid of a Vanguard Motion Analyser, Model M-160. This resulted in the times being determined for clearing the starting blocks and reaching each of the chosen displacement points throughout the 27 metre course.

3.82 Statistical Analysis of the Data.

The time measures of each subject for each type of start were averaged. The averaged scores of the subjects were then used to calculate the mean scores for the standing start and crouch start performance.

A two-way analysis of variance with repeated measures on distance was carried out in order to determine the extent of any difference between the standing start and the crouch start performance

A post hoc test of simple main effects determined at which time measure, statistically significant difference occurred.

# CHAPTER IV

# RESULTS

## 4.1 Overview.

The mean performance times for clearing the starting blocks and reaching each of the selected displacement points for trials from the standing and crouch starting positions, are recorded in Table III, together with the standard deviations.

The mean performance times were analysed by using a two way analysis of variance with repeated measures on the displacement points. As expected, this treatment yielded highly significant differences for the displacement points (factor B) but since the mean times at the displacement points were cumulative, this was of no consequence. Of much greater importance was the significant interaction between Type of Start X Displacement (Factor A x Factor B ). A post hoc test of simple main effects was performed in order to ascertain where the significant difference occurred. It was found that there was a significant difference at the .05 level of confidence in favour of the crouch start over the standing start, in the amount of time taken to clear the starting blocks. The results of this treatment are shown in Table IV.

TABLE III

Mean Times and Standard Deviations for the Time taken to clear the Starting Blocks and reach each Displacement Point, to the nearest 1/100 th sec

| Displacement Point | Standing Start $\bar{X}$ | Standing Start S.D. | Crouch Start $\bar{X}$ | Crouch Start S.D. | $\bar{X}$ | S.D. |
|---|---|---|---|---|---|---|
| Clearing Blocks | 0.46 | 0.27 | 0.33 | 0.16 | 0.40 | 0.09 |
| 1.5 metres | 0.68 | 0.17 | 0.64 | 0.00 | 0.66 | 0.06 |
| 9.0 metres | 1.91 | 0.10 | 1.86 | 0.16 | 1.88 | 0.05 |
| 13.72 metres | 2.57 | 0.12 | 2.52 | 0.16 | 2.55 | 0.08 |
| 18.0 metres | 3.14 | 0.10 | 3.06 | 0.16 | 3.11 | 0.08 |
| 22.86 metres | 3.84 | 0.10 | 3.76 | 0.16 | 3.80 | 0.08 |
| 27.0metres | 4.39 | 0.12 | 4.30 | 0.16 | 4.34 | 0.09 |

4.2 Combined Data for Clearing the Starting Blocks and Reaching each Displacement Point

4.21 Clearing the Starting Blocks ($S_{xo}$)

| | Standing Start | Crouch Start |
|---|---|---|
| Time taken | 0.46sec | 0.33sec |

There was a significant difference at the .05 level of confidence in favour of the crouch start over the standing start.

TABLE IV

ANOVAR Table for the Standing Start Versus the Crouch Start.

| Source of Variation | df | Sums of Squares | Mean Squares | * | p |
|---|---|---|---|---|---|
| Between Ss | 9 | 0.396 | | | |
| Type of Start (A) | 1 | 0.090 | 0.090 | 2.36 | > .05 |
| A at Blocks | 1 | 0.03[illegible] | 0.03[illegible] | 6.22 | < .05 |
| A at 1.5m | 1 | 0.004 | 0.004 | 0.71 | |
| A at 9.0m | 1 | 0.00[illegible] | 0.00[illegible] | 1.27 | |
| A at 13.72m | 1 | 0.00[illegible] | 0.00[illegible] | 1.27 | |
| A at 18.0m | 1 | 0.00[illegible] | 0.00[illegible] | 1.36 | |
| A at 22.56m | 1 | 0.015 | 0.015 | 2.46 | |
| A at 27.0m | 1 | 0.020 | 0.020 | 3.2[illegible] | |
| Ss Within Groups | [illegible] | 0.306 | 0.03[illegible] | | |
| Within Ss | 60 | 135.726 | | | |
| Displacement (B) | 6 | 135.654 | 22.614 | 34735.04 | < .0001 |
| B at Standing Start | 6 | 67.7[illegible]4 | 11.297 | 11297.2[illegible] | < .0001 |
| B at Crouch Start | 6 | 67.912 | 11.319 | 1131[illegible].65 | < .0001 |
| Start x Displacement A x B | [illegible] | 0.012 | 0.002 | 2.96 | < .025 |
| B x Ss Within Groups | 48 | 0.031 | 0.001 | | |

* For 1,8 df F must equal or exceed 5.32 for significance at the .05 level.

For 6,48 df F must equal or exceed 2.69 and 3.20 for significance at the .025 and .01 levels respectively.

4.22 <u>1.5</u> <u>metres</u> ($S_{xil}$)

There was no significant difference between the standing sprint start position and the crouch sprint start position in the time taken to reach 1.5 metres.

TABLE V

Data at $S_{xil}$

| | Standing Start | Crouch Start |
|---|---|---|
| S | 1.5m | 1.5m |
| $\Delta S_{xil}$ ($S_{xil} - S_o$) | 1.5m | 1.5m |
| t | 0.68 sec | 0.64 sec |
| $\Delta t_{il}$ ($t_{il} - t_o$) | 0.68 sec | 0.64 sec |
| Vt | 4.42 m/sec | 4.6[illegible] m/sec |
| $\overline{V}$ | 2.20 m/sec | 2.34 m/sec |
| a | 6.50 m/sec$^2$ | 7.2[illegible] m/sec$^2$ |

4.23 9.0 metres $S_{x12}$

There was no significant difference between the standing sprint start position and the crouch sprint start position in the time taken to reach 9.0 metres.

TABLE VI

Data at $S_{x12}$

| | Standing Start | Crouch Start |
|---|---|---|
| $S$ | 9.0m | 9.0m |
| $\Delta S_{x12}$ $(S_{x12} - S_{x11})$ | 7.5m | 7.5m |
| $t$ | 1.92 sec | 1.86sec |
| $\Delta t_{12}$ $(t_{12} - t_{11})$ | 1.24 sec | 1.22sec |
| $v_t$ | 7.73m/sec | 7.92m/sec |
| $\bar{v}$ | 6.07m/sec | 6.16m/sec |
| $a$ | 2.66m/sec$^2$ | 2.66m/sec$^2$ |

4.24 <u>13.72 metres</u> ($S_{x13}$)

There was no significant difference between the standing sprint start position and the crouch sprint start position in the time taken to reach 13.72 metres.

TABLE VII

Data at $S_{x13}$

| | Standing Start | Crouch Start |
|---|---|---|
| S | 13.72m | 13.72m |
| $\Delta S_{x13}(S_{x13} - S_{x12})$ | 4.72m | 4.72m |
| t | 2.57sec | 2.52sec |
| $\Delta t_{13}(t_{13} - t_{12})$ | 0.66sec | 0.66sec |
| Vt | 6.57m/sec | 6.40m/sec |
| $\bar{V}$ | 7.17m/sec | 7.17m/sec |
| a | $-1.76 m/sec^2$ | $-2.23 m/sec^2$ |

4.25 18.0 metres ($S_{x14}$)

There was no significant difference between the standing sprint start position and the crouch sprint start position in the time taken to reach 18.0 metres

TABLE VIII

Data at $S_{x14}$

| | Standing Start | Crouch Start |
|---|---|---|
| S | 18.0m | 18.0m |
| $\Delta S_{x14}$ ( $S_{x14} - S_{x13}$ ) | 4.28m | 4.28m |
| t | 3.14sec | 3.08sec |
| $\Delta t_{14}$ ( $t_{14} - t_{13}$ ) | 0.57sec | 0.57sec |
| Vt | 8.50m/sec | 8.90m/sec |
| $\bar{V}$ | 7.54m/sec | 7.56m/sec |
| a | 3.40m/sec$^2$ | 4.42m/sec$^2$ |

4.26 22.86 metres ( $S_{x15}$)

There was no significant difference between the standing sprint start position and the crouch sprint start position in the time taken to reach 22.86 metres.

TABLE IX

Data at $S_{x15}$

| | Standing Start | Crouch Start |
|---|---|---|
| S | 22.86m | 22.86m |
| $\Delta S_{x15}$ ($S_{x15}$- $S_{x14}$) | 4.86m | 4.86m |
| t | 3.84sec | 3.76sec |
| $\Delta t_{15}(t_{15}-t_{14})$ | 0.70sec | 0.68sec |
| Vt | 5.38m/sec | 5.40m/sec |
| $\bar{V}$ | 6.94m/sec | 7.14m/sec |
| a | $-4.47m/sec^2$ | $-5.14m/sec^2$ |

4.27 27.0 metres ($S_{x16}$)

There was no significant difference between the standing sprint start position and the crouch sprint start position in the time taken to reach 27.0 metres.

TABLE X

Data at $S_{x16}$

| | Standing Start | Crouch Start |
|---|---|---|
| S | 27.0m | 27.0m |
| $\Delta S_{x16}(S_{x16} - S_{x15})$ | 4.14m | 4.14m |
| t | 4.39sec | 4.30sec |
| $\Delta t_{15}(t_{16} - t_{15})$ | 0.55sec | 0.53sec |
| Vt | 9.76m/sec | 10.11m/sec |
| $\bar{V}$ | 7.62m/sec | 7.75m/sec |
| a | 8.04m/sec$^2$ | 8.82m/sec$^2$ |

4.3 Velocity Patterns of the Subjects.

Knowing the time taken to reach each displacement point, as shown in figure 7, the velocity at these displacement points was calculated. ( $Vt = \frac{2\Delta S}{\Delta t} - Vo$). The data is illustrated in figure 8. Velocity increases throughout the run except where the hurdles are cleared at $S_{x13}$(13.72m) and $S_{x15}$ (22.86m). The velocity is less at $S_{x15}$ than it is at $S_{x13}$. At each of the displacement points $S_{x12}$(9.0m) , $S_{x14}$(18.0m) and $S_{x16}$(27.0m), which are not affected by take off preparation and landing before and after each hurdle, increasing velocity is observed for trial runs from both the standing and the crouch starting positions. This data is reported in Table XI.

4.4 Acceleration and Deceleration of the Subjects.

The acceleration and deceleration for trials from each of the starting positions was calculated for each of the displacement points ($a = \frac{Vt - Vo}{\Delta t}$ ). The data is reported in Table XII. At each hurdle clearance deceleration is observed. This data is illustrated in figure 9.

4.5 Fastest Trial Runs

Four of the subjects achieved their fastest time to 27.0m when the crouch start was used and only one achieved his fastest time to 27.0m from the standing start position.

4.6 Steps to the First Hurdle.

When the standing start was used, three subjects used a

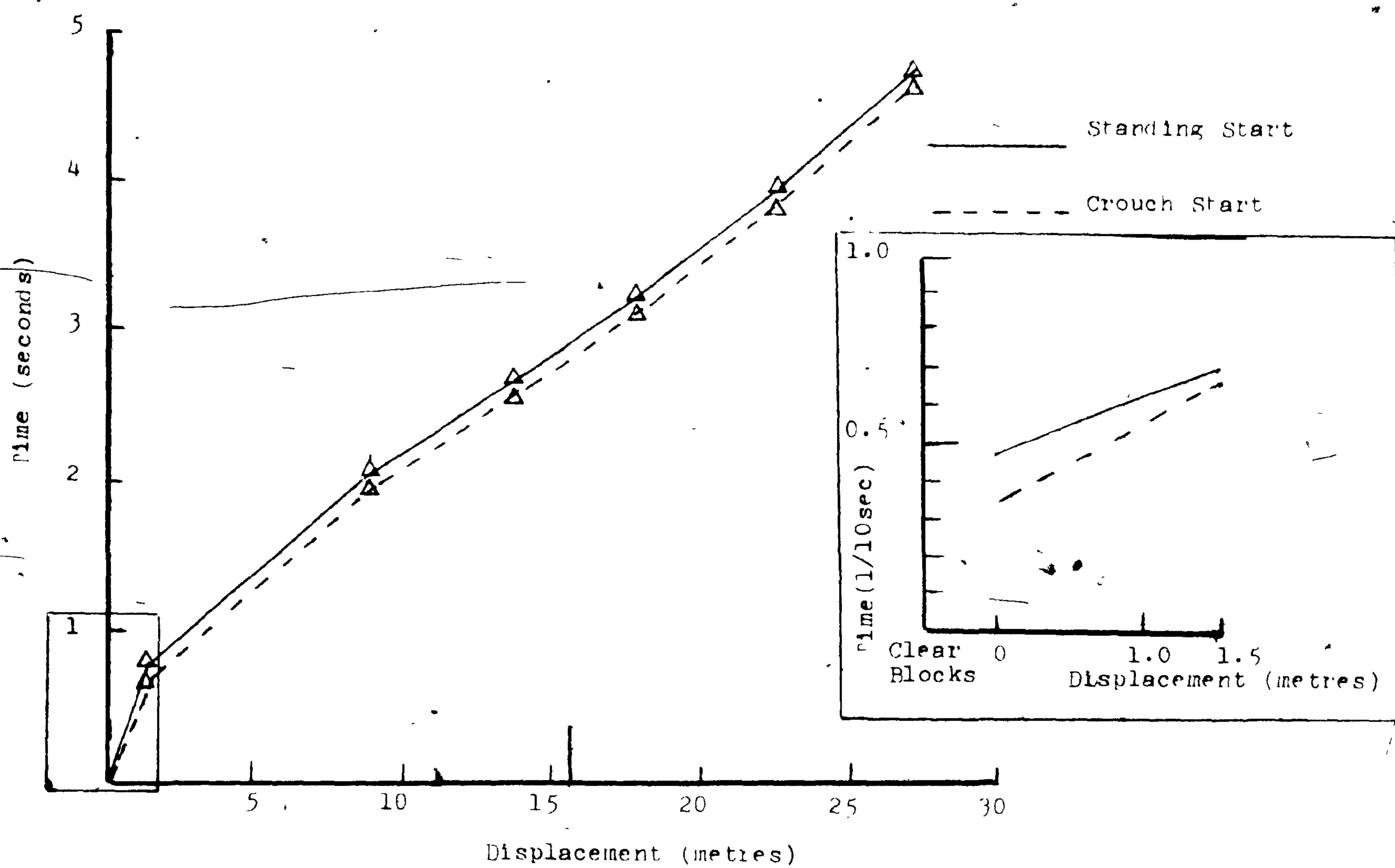


Figure 7 A Comparison of the Displacement produced by the Standing and the Crouch Sprint Starts.

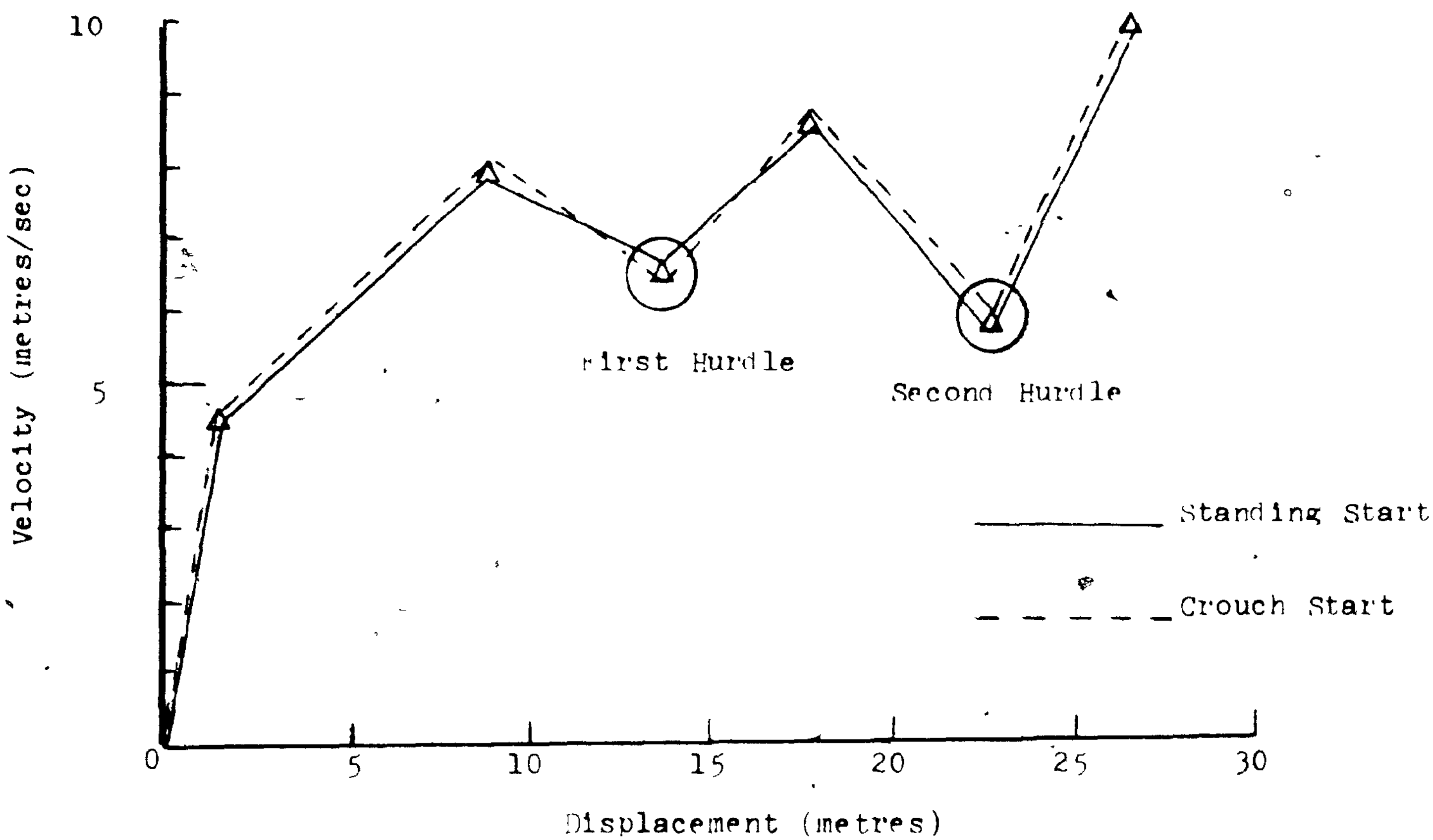


Figure 8 A Comparison of the Velocity produced by the Standing and the Crouch Sprint Starts.

TABLE XI

Velocity (m/sec) at each Displacement Point for Trials from the Standing and Crouch Start Positions.

| Displacement Point | | Standing Start | Crouch Start |
|---|---|---|---|
| $S_{xi1}$ | 1.5m | 4.42 | 4.68 |
| $S_{xi2}$ | 9.0m | 7.73 | 7.92 |
| $S_{xi3}$ | 13.72m | 6.57 | 6.40 |
| $S_{xi4}$ | 18.0m | 8.50 | 8.90 |
| $S_{xi5}$ | 22.86m | 5.38 | 5.40 |
| $S_{xi6}$ | 27.0m | 9.76 | 10.11 |

TABLE XII

Acceleration/ Deceleration (m/sec$^2$) at each Displacement Point for Trials from the Standing and the Crouch Sprint Starting Positions.

| Displacement Point | Standing Start | Crouch Start |
|---|---|---|
| $S_{xi1}$ | 6.5 | 7.28 |
| $S_{xi2}$ | 2.68 | 2.66 |
| $S_{xi3}$ | -1.76 | -2.23 |
| $S_{xi4}$ | 3.40 | 4.42 |
| $S_{xi5}$ | -4.47 | -5.14 |
| $S_{xi6}$ | 8.04 | 8.82 |

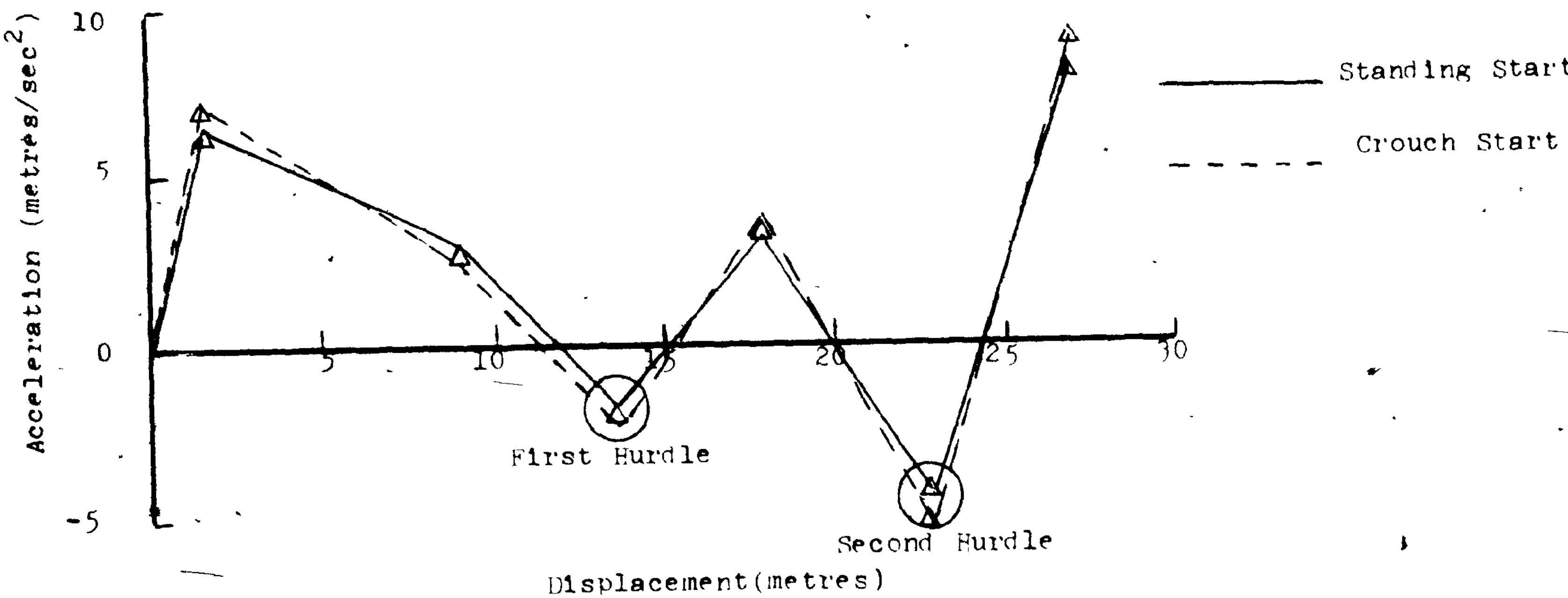


Figure 9 A Comparison of the Acceleration produced from the Standing and the Crouch Sprint Starts

seven stride approach to the first hurdle and two subjects used an eight stride approach. With the crouch start, one subject used a seven stride approach and the other four subjects used an eight stride approach.

4.7 Discussion.

4.71 Clearing of the Starting Blocks.

The advantage of the crouch start over the standing start was that it allowed subjects to clear the starting blocks in a significantly faster time at the .05 level of confidence. May (17) found, that his subjects also cleared the starting blocks in a significantly faster time with the crouch start as compared to the standing start. Ward (30) reported a 0.8 second faster mean block clearance time for the crouch start as compared to the standing start.

It appears that the four point stance of the crouch start allows subjects to achieve a more stable, motionless 'set' position closer to overbalance than the one which can be attained with the two point stance of the standing start 'set' position; thereby possibly facilitating faster clearance of the starting blocks.

4.72 Results at 1.5 metres.

There was no significant difference in the times recorded at 1.5 metres in runs from the two starting positions. However, the 0.13 second advantage of the crouch start for the starting block clearance was 0.4 second at 1.5 metres.

Since the velocity of the crouch start at 1.5 metres was 0.24m/sec faster than that of the standing start, the better performance of the standing start to 1.5 metres, after the starting blocks were cleared, must be due to the fact that the front starting block is closer to the starting line.

The time gained by the standing start during this phase of the run, was less than the time which was lost in the starting blocks, so the cumulative times of 0.64 sec for the crouch start and 0.66 sec for the standing start gave a slight, but statistically not significant advantage, to the crouch start.

4.73 <u>Results at all the other Displacement Points</u>

There was no significant difference in the times recorded at 9.0, 13.72, 18.0, 22.86 and 27.0 metres for the trial runs from the standing and the crouch sprint starting positions. Throughout the course, the times for the two starting positions were very close and the mean times at each displacement point slightly favoured the crouch starting position.

4.74 <u>Velocity Patterns of the Subjects</u>

The velocity patterns of the two starts are almost identical after the 1.5 metre displacement point. Since velocity was increas -ing at the end of the run, it is doubtful if maximum velocity was achieved during the 27.0 metre course. Since no time measure is known beyond the course, it is not possible to be certain. At displacement points not affected by hurdle clearance, velocity increased as the displacement from the starting line became greater. There is a marked decrease in velocity for hurdle clearance and a subsequent increase in velocity at the displacement point after the hurdle.

Velocity at the second hurdle was less than at the first hurdle. It appears that the seven or eight stride approach to the first hurdle allows a more efficient hurdle clearance than the three stride approach to the second hurdle. This study, with the camera set at a minimum distance of 80' from the subject, was not planned to analyse this aspect of hurdling. The image size of the foot on the film was too small to give precise measurement for the instant the take-off foot left the ground before the hurdle, to the instant the trailing foot left the ground after the landing beyond the hurdle.

The scientifically collected data does indicate the need for skillfull hurdling technique, in order to minimise the velocity decrease at each hurdle clearance.

4.75 <u>Acceleration and Deceleration of the Subjects</u>.

At the first hurdle, deceleration of - 1.76 m/sec$^2$ from the standing start was less than the - 2.23 m/sec$^2$ of the crouch start trials. This was consistent with the data at the second hurdle, where deceleration for standing start trials was - 4.47 m/sec$^2$ as compared to - 5.14 m/sec$^2$ for the crouch start. This seems to demonstrate that hurdle clearance from the standing start position was more efficient than from the crouch start position.

Surprisingly however, after each hurdle clearance, acceleration to the next displacement point is greater from the crouch start position. The difference after the first hurdle ([illegible].42 $m/sec^2$ : [illegible].46 $m/sec^2$) is greater than the difference after the second hurdle ([illegible].6[illegible] $m/sec^2$ : [illegible].[illegible]2 $m/sec^2$).

It would have been most interesting to have been able to see how this pattern progressed throughout the whole 110 metre distance.

4.76 Fastest Trial Runs.

Four of the subjects achieved their fastest trial time to 27.0 metres from the crouch sprint starting position. The subject whose best performance came from the standing start position was the tallest subject in the group, with a height of 6' 3".

It is quite likely that the standing start may be a better starting position for some athletes. There is no statistically significant difference between the two types of start in the time taken to reach 27.0 metres.

There is also the possibility that a tall athlete may have more success with the standing start than with the crouch start. During the training period before testing, this one subject decided to use the standing start in competition and was able to record his best time. The trial run in testing was not therefore a single isolated performance.

4.77 Steps to the First Hurdle.

When the standing start was used, three subjects used a seven stride approach to the first hurdle and two used an eight stride approach. With the crouch start, one subject used a seven stride approach and the other four used an eight stride approach.

It was thought that the front starting block placement, since it was closer to the starting line, might facilitate a smoother, easier and faster approach to the first hurdle. The subjects agreed that the approach felt to be easier and smoother, but the subjective opinion was not accompanied by better times at the first hurdle. The reason for this is clearly the significantly longer time taken to clear the starting blocks when the standing start is used.

# CHAPTER V

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Summary

The purpose of this study was to determine whether the standing sprint start position, when compared to the crouch sprint start position, allowed a superior performance over the initial 27.0 metres of a men's 110 metre high hurdle course.

A comparison was done on the amount of time taken to clear the starting blocks and to reach the displacement points of 1.5, 9.0, 13.72, 18.0, 22.86 and 27.0 metres.

The subjects were five caucasian, currently competitive hurdlers of provincial calibre. They were taught the standing start and practiced it for a six week period prior to testing.

For the standing start, a special block designed by Bob Clark (4) was used in conjunction with a Martin's Crystal Palace Cantabrian block. The rear block was extended to 10"/4" to provide better support for the foot. The front block was placed 2" behind the starting line and the rear block 20" to 24" behind the front block, depending on the size of the subject.

An Arnett block was used for the crouch start with the front block being between 14" ~~to 19"~~ behind the starting line and the rear block 33" to 37 " behind the starting line.

The testing was done in one session of filming on an outdoor all weather track. Filming was accomplished by using two Locam motion picture cameras. The cameras were synchronised by means of a custom designed control box and could be started and stopped simultaneously or individually from one external source. One camera was placed 15' from the starting line and operated at 300 frames per second, taking close-up pictures of starting block clearance. The second camera was placed 80' back from the side of the first hurdle and took pictures of the whole 27.0 metres run at 150 frames per second. A Red Lakes Laboratory Mille Mite timing light generator marked the film at every 1/100th of a second.

Each subject performed two 27.0 metre runs from the standing start position and two from the crouch starting position. The processed film was analysed with a Vanguard Motion Analyser. This resulted in times being determined for clearing the starting blocks and reaching the displacement points of 1.5, 9.0, 13.72, 18.0, 22.86 and 27.0 metres.

A two way analysis of variance with repeated measures on distance was carried out in order to determine the extent of the difference between the standing and crouch start performance. A post hoc test of simple main effects determined at what time measure the statistically significant differences occured.

It was found that there was a significant difference at the .05 level of confidence in favour of the crouch start over the standing start in the amount of time taken to clear the starting blocks. There was no significant difference in timed performance at 27.0 metres or at any other selected displacement point.

Velocity showed an expected decrease at each hurdle clearance and a subsequent increase a the displacement points not affected by take-off preparation and landing. Velocity was slightly lower at the second hurdle than at the first. Greatest velocity came at the end of the 27.0 metre course.

Four of the subjects did their fastest run from the crouch start position and only one from the standing start position. Three subjects were able to approach the first hurdle in seven strides when the standing start was used as compared to one when the crouch start was used. However, this did not result in the standing start giving a faster time at the first hurdle, because of the significantly longer time taken to clear the starting blocks.

Though the crouch starting position did give a significantly faster block clearance time, the advantage was not maintained and at all other displacement points there was no significant difference in timed performance from the two starting positions.

5.2 Conclusions

Within the confines and limitations of this study, the following conclusions seem justified.

5.21 There is no significant difference between the time taken to reach 27.0 metres of the mens high hurdle course when the standing sprint start position and the crouch sprint start position are used.

5.22 The time taken to clear the starting blocks once the first reponse to the gun has been made, is significantly lower for the crouch start as compared to the standing start.
5.23 There is no significant difference between the times taken to reach the displacement points of 1.5, 9.0, 13.72, 18.0 and 22.86 metres whether the standing start or the crouch sprint start is used.
5.24 The standing start can be considered as an acceptable alternative starting position to the crouch sprint start. The decision whether or not to use it will be an individual one on the part of the athlete concerned, after his particular abilities have been taken into consideration.

5.3 Recommendations

The following recommendations are made for further study.
5.31 A study should be done comparing the standing start perormance time given by the Clark block used in this study and a Leflar Highback Block shown in figure 10.
5.32 The standing start performance and the crouch start performance of a sample of subjects over 6'1" in height should be compared with the performance of a subject sample whose height is under 5'10".
5.33A study should be done on the amount of time taken to clear each hurdle in the mens 110 metre hurdle race.
5.34 Standing sprint start studied should be undertaken using women subjects.

# THE HIGHBACK BLOCK

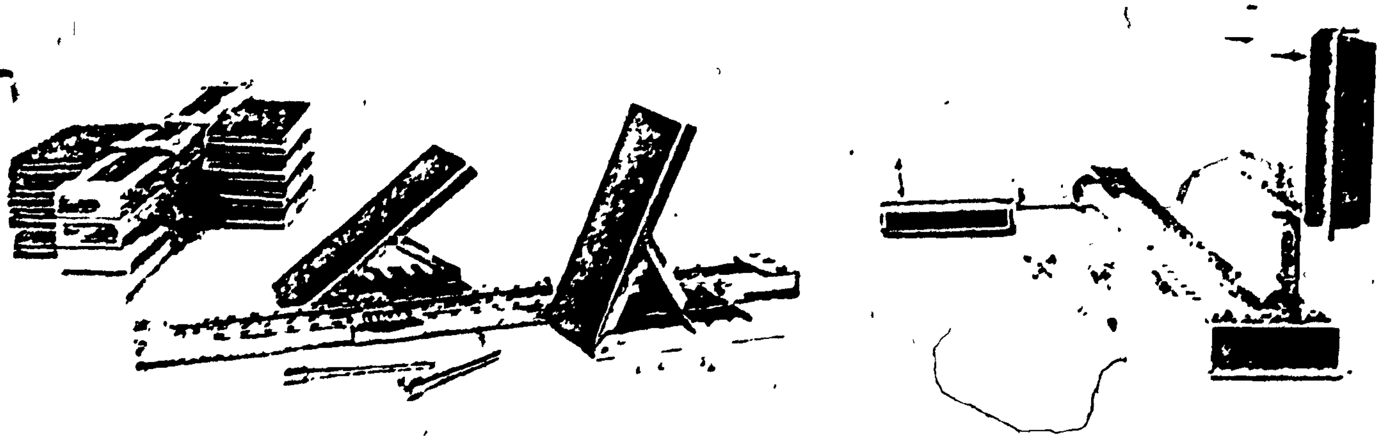

Figure 10. The Highback Leflar Block.

BIBLIOGRAPHY

1. Best, C.H. and Partridge, R.C., "Observations on Olympic Athletes", Proceedings of the Royal Society of London. Series B. 105:22:1930.

2. Bowerman, B., "The Secret of Speed" Sports Illustrated, 35:22:1971.

3. Bruning, J.L. and Kintz, B.L., "Computational Handbook of Statistics", Scott, Foreman and Co., Glenview, Ill. 1968.

4. Clark, B. "The Standing Start". Scholastic Coach, 40:114:1971.

5. Desipres, M., Comparison of the Kneeling and Standing Sprint Starts: A Cinematographical Analysis Incorporating Electromyography, Unpublished Report, University of the Orange Free State, Bloemfontein, South Africa. 1972. 8 pp.

6. Dickinson, A.D. "The Effect of Foot Spacing on the Starting Time and Speed in Sprinting and the Relation of Physical Measurement to Foot Spacing", Research Quarterly, 5:12:1934.

7. Ecker, T., and Hay, J., "The Standing Start", Athletic Journal, 53:14:1971.

8. Henry, F.M., "Force Time Characteristics of the Sprint Start", Research Quarterly, 23:301:1952.

9. Henry, F.M. and Trafton, I.R., The Velocity Curve of Sprint Running", Research Quarterly, 22:409:1951.

10. Gagnon, Micheline, "The Biomechanics of the Sprint Start" *Unpublished Master's Thesis*, Pennsylvania State University, University Park, 1969, 103 pp.

11. Hipple, J., "Warm up and Fatigue in Junior High School Sprinters", *Research Quarterly*, 26:246:1955.

12. Ikai, M., "Biomechanics of Sprint Running with Respect to the Speed Curve", *Medicine and Sport*, 2:282:1968.

13. Jerome, H., "A Study of the Effectiveness of Three Models of Starting Blocks and of a Series of Six Starts in a Forty Yard Sprint", *Unpublished Master's Thesis*, University of Oregon, 1968. 46pp.

14. Kistler, J.W., "A Study of the Distribution of the Force Exerted in the Starting of the Sprint from Various Starting Positions", *Research Quarterly*, 5:27:1934.

15. Lacy, D.E., "The Interrelation Between Reaction Time and Velocity in Different Parts of the Sprint Run", *Unpublished Thesis*, University of California, Berkeley, 1941.

16. Mathews, K., and Snyder, H.A. "The Effect of Warm-Up on the 440 Yard Dash", *Research Quarterly*, 26:246:1955.

17. May, R.F. Jr., "A Comparison of the Standing and Crouch Track Starts on Response Time and Velocity Over the Initial Fifteen Yards", *Unpublished Doctoral Thesis*, Louisiana State University, 1972.

18. McGavin, R.J., "The Effect of Different Warm-Up Exercises of Varying Intensities on Speed of Leg Movement", *Research Quarterly*, 36:35:1968.

19. Menely, R.C. and Rosemier, R.A., "Effectiveness of Four Track starting Positions on Acceleration", Research Quarterly, 39:161:1968.

20. Payne, A.H., and Blader, F.B., "The Mechanics of the Sprint Start", Medicine and Sport, edited by Ernest Jokl, S.Karger, New York, 1971.

21. Scott, Gladys,M., Ed., "Research Methods Applied to Health, Physical Education and Recreation". A.A.H.P.E.R. Washington, 1969.

22. Sigerseth, P.O., and Grinaker, V.F., "Effect of Foot Spacing on Velocity in Sprints", Research Quarterly, 33:599:1962.

23. Short, J., "Standing Start Modernised", Track Technique 37:1227:1962.

24. Sills, F.D., and Pennybaker, D.A., " A Method of Measuring Velocity of Movement with a Cathode Ray Oscillograph", Proceedings, Twenty-Second Convention, Central District, American Association for Health, Physical Education and Recreation, 22:24:1956.

25. Stock, M., "Influence of Various Track Starting Positions on Speed", Research Quarterly, 33:607:1962.

26. Toomasulu, H., "Sprint Speed Factors ", Track Technique, 11:325:1973.

27. Trynlecki, J., Pilot Study: "Standing Start versus Bunch Start", Unpublished Research, Southeastern Louisiana University, Hammond, 1970.

28. Walker, G.A., and Hayden, T.C., " The Optimum Time for Holding a Sprinter Between 'Sets' and the Stimulus(Gun Shot), "Research Quarterly, 4:124:1933

29. Walker, G.A., and Hayden, T.C.," A Comparison of the Starting Times of Runners Using Holes in the Track and Starting Blocks", Research Quarterly, 33:117:1933.

30. Ward, P.-., "An Analysis of Kinetic and Kinematic Factors of the Standup and the Preferred Crouch Starting Techniques with Respect to Sprint Performance", Unpublished Doctoral Thesis, University of Indiana, 1973.

31. Webster, .A.M., Olympic Cavalcade,(London:Hutchinson & Co.,Ltd.),1948.p.48.

32. ________________ " On Your Marks", World Sports, 36: May, 1970.

## APPENDIX A

### Standing Start

| | Clear Blocks | 1.5m | 9.0m | 13.72m | 18.0m | 22.86m | 27.0m |
|---|---|---|---|---|---|---|---|
| 1. | 0.44 | 0.66 | 1.92 | 2.58 | 3.16 | 3.85 | 4.38 |
| 2. | 0.47 | 0.68 | 1.89 | 2.54 | 3.10 | 3.78 | 4.32 |
| 3. | 0.35 | 0.57 | 1.79 | 2.44 | 3.01 | 3.69 | 4.25 |
| 4. | 0.58 | 0.83 | 2.06 | 2.75 | 3.29 | 4.00 | 4.57 |
| 5. | 0.45 | 0.68 | 1.92 | 2.56 | 3.15 | 3.89 | 4.42 |
| $\bar{X}$ | 0.46 | 0.68 | 1.91 | 2.57 | 3.14 | 3.84 | 4.38 |

### Crouch Start

| | Clear Blocks | 1.5m | 9.0m | 13.72m | 18.0m | 22.86m | 27.0m |
|---|---|---|---|---|---|---|---|
| 1. | 0.35 | 0.66 | 1.89 | 2.56 | 3.14 | 3.83 | 4.32 |
| 2. | 0.33 | 0.65 | 1.87 | 2.48 | 3.03 | 3.70 | 4.22 |
| 3. | 0.30 | 0.64 | 1.85 | 2.49 | 3.08 | 3.77 | 4.33 |
| 4. | 0.33 | 0.62 | 1.84 | 2.56 | 3.09 | 3.76 | 4.30 |
| 5. | 0.36 | 0.64 | 1.85 | 2.50 | 3.08 | 3.76 | 4.32 |
| $\bar{X}$ | 0.33 | 0.64 | 1.86 | 2.51 | 3.08 | 3.76 | 4.29 |

The averaged times for each subjects two standing start and two crouch start trials and the mean times at each displacement point. (Times to nearest 1/100th sec).

## APPENDIX [illegible]

### Standing Start

| | | | | | | |
|---|---|---|---|---|---|---|
| S(metres) | 1.5 | 9.0 | 13.72 | 18.0 | 22.86 | 27.0 |
| ΔS(metres) | 1.5 | 7.5 | 4.72 | 4.28 | 4.86 | 4.14 |
| t(sec) | 0.68 | 1.92 | 2.57 | 3.14 | 3.84 | 4.39 |
| Δt(sec) | 0.68 | 1.24 | 0.66 | 0.57 | 0.70 | 0.55 |
| Vt(m/sec) | 4.42 | 7.73 | 6.57 | [illegible].50 | 5.38 | 9.76 |
| $\bar{V}$(m/sec) | 2.20 | 6.07 | 7.17 | 7.54 | 6.94 | 7.62 |
| a(m/sec$^2$) | 6.50 | 2.68 | -1.76 | 3.40 | -4.47 | [illegible].04 |

### Crouch Start

| | | | | | | |
|---|---|---|---|---|---|---|
| S(metres) | 1.5 | 9.0 | 13.72 | 18.0 | 22.86 | 27.0 |
| ΔS(metres) | 1.5 | 7.5 | 4.72 | 4.28 | 4.86 | 4.14 |
| t(sec) | 0.64 | 1.86 | 2.52 | 3.08 | 3.76 | 4.30 |
| Δt(sec) | 0.64 | 1.22 | 0.66 | 0.57 | 0.68 | 0.55 |
| Vt(m/sec) | 4.68 | 7.92 | 6.40 | [illegible] | 5.40 | 10.11 |
| $\bar{V}$(m/sec) | 2.34 | 6.16 | 7.17 | 7.56 | 7.14 | 7.755 |
| a(m/sec$^2$) | 7.28 | 2.66 | -2.23 | 4.42 | -5.14 | [illegible].82 |

Data for the standing and crouch sprint starting positions.