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The purpose of this study was to determine if a weight training program, used as a supplementary program to a conventional sprint training program, would improve the speed of the sprinters.

Seventy-one ninth grade boys participated in the study. There were two groups, the experimental group (A) and the control group (B). Group A had thirty-eight boys while group B had only thirty-three boys. The study was carried out Monday through Friday of each week for a period of six weeks. The control group (B) performed only a designed program of sprint training, while the experimental group (A) used a supplementary program of weight training with the sprint training program.

The raw data of the means were treated statistically through a "t" test to determine if there were a significant difference at the .05 level of confidence.

From the results of this study it is concluded that weight training, when used as a supplement to sprint training does increase the running speed of the sprinter.

COMPARISON OF TWO METHODS

OF IMPROVING SPEED IN THE 100 YARD DASH

by

Gilbert Buck

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APPROVAL SHEET

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CHAPTER I

INTRODUCTION

Track coaching methods have been a controversial issue for many years among dedicated men involved in the attempt to improve human speed.

The problem of improving one's speed in sprinting has been dealt with in various ways and has been broken down into many phases with each phase being tested and developed for maximum efficiency. Phases from start to finish have been studied by various coaches. Utilizing the data from years of research, coaches have developed methods by which their runners train. Runners have based their programs upon sound logic, physiological research, and mechanical evidence to the point that almost every move is a science. (17,8,19,1,15,16)

This researcher first became interested in this problem while coaching high school football and basketball. The lack of leg strength and speed in many of the boys participating in these sports was quite noticeable. Various training programs and drills were incorporated into the programs in an attempt to improve speed and performance as quickly as possible, but very little success was attained. It was at this time that this researcher first decided to investigate methods of improving running speed through a scientific training program.

Statement of problem

The purpose of this study was to determine if a weight training program, used as a supplementary program to a conventional method of sprint training, would improve the speed of sprinters.

Null hypothesis

A supplementary weight training program will not increase the running speed of sprinters.

Definitions of terms

Conventional method of sprint training: The routine procedure of exercises, warm-up drills, and practice schedules used by sprinters.

Weight training program: A supplementary training program utilizing bar bells to overload and strengthen the muscles used in sprinting.

Driving force of the leg: The amount of pressure put on the leg as the sprinter leaves the starting blocks and the force exerted on the legs when reaching full-speed strides.

Leg recovery: The replacing of the foot and leg, from under the buttock, to the point of impact with the ground while running.

Progressive resistance method of training: The addition of resistance (weight) to the exercise being used to maintain an over-load as the participant's strength increases.

Inertia: The amount of natural resistance to the sprinter as he attempts to reach maximum speed and the resistance as the sprinter tries to reduce his speed from his maximum.

Transitional stride or pick-up: The increasing length of each stride used after leaving the starting blocks to attain maximum speed, usually for a distance of approximately 15 yards.

Basic assumptions

1. It is a general feeling of physical educators and athletic coaches that running and muscle building exercises tend to improve the individual's performance.

2. Weight training for various muscles is accepted as a muscle builder for a greater degree of efficiency in sports, especially in leg strength for football.

3. Even though many people can improve their speed somewhat through exercise, the human can only run so fast, with some individuals being innately faster than others.

4. "Natural leg speed is controlled by the speed at which nerve impulses travel in the individual, and by the speed at which the muscles themselves can respond to these impulses." (17:12)

Delimitations

This study was limited by the following factors:

1. The subjects could not be controlled outside the training program.

2. A number of the subjects were involved with the sport in season after school, receiving additional exercise. However, the number of students involved were divided equally between the two groups.

3. Other school functions often interfered with one group or the other. When one group missed a class, the other group was not permitted to train.

4. The study was administered out-of-doors, where weather conditions prolonged the program and may have affected speed.

Significance

A supplementary weight training program which will help to increase the speed of sprinters would be very beneficial to high school and college coaches throughout the country. On the other hand, if the supplementary weight program should show no speed improvement, many coaches might disregard the time consuming and useless exercises and spend more time on techniques.

CHAPTER II

REVIEW OF LITERATURE

This chapter will include several studies of the effects of training programs on performances. A complete muscular analysis of movement in running would be almost impossible; however, a good coverage of the aspects of sprinting is valuable.

Analysis of Running

Running is a pendulum type of movement like walking; however, when running at top speed, as does the sprinter, it may not be so classified. The factors most notable in differentiating the run from the walk are the period of double support, characteristic of the walk but not present in the run, and the period of no support. (a sailing-through-the-air period), characteristic of the run but not present in the walk. (19:430) In running, the foot hits the ground almost directly under the center of gravity of the body. While walking, the foot hits the ground in front of the body. The foot striking the ground under the center of gravity reduces the restraining part of the supporting phase and gives greater emphasis to the propulsive part. In running, the force exerted to produce the movement has two components, horizontal and vertical. Because of the tremendous increase in horizontal force, the vertical component is relatively unimportant. Regardless of the speed of any run, the economy of effort is a highly desirable objective.

The laws of motion play a tremendous role in the running speed.

The first law of motion deals with inertia from the start of the run until maximum speed is reached; the second law of motion deals with the force of the runner, while the third law of motion deals with the opposite reaction to every action. Other principles of running include the leverage of the runner, the height, the power of the stride, excessive lateral movements, and the elimination of excessive forces.

To achieve these running principles, the runner must observe certain principles which apply to efficient running. (19:431-432) (See Appendix)

Training Programs

A good training program is of great importance to any athlete, sprinting being no exception.

Bresnahan (2:79) states that each event requires a different type of warm-up utilizing breathing and abdominal exercises, stretching of arms and legs, and jogging exercises to regulate the body for the following event in which the individual plans to participate. According to Bakjian, (1:48) a good conditioning program prevents mid-season failures, and when an athlete feels he is in good track condition, he is confident and he has a better competitive spirit.

Not only are the programs for conditioning and the drills for warm-ups important, but, according to Rankin, (15:18) it is necessary to develop a training program of pre-season, early season, competitive season, and late-competitive season training. The pre-season program should begin with the development of the total body endurance. Early season work tends more toward the development of individual muscle groups, but also has to deal with speed development and skill work. The competitive season program deals with a mixture of the training methods, but the concentration is on reaction of movement and progression of skills (techniques). The late or competitive season program is one of concern, and is for the purpose of maintaining a type of training. (14:18)

Very little information can be found concerning the lone effects of a supplementary weight training program on an individual's running speed. However, many attempts have been made in different ways to improve speed.

In a study by Dintiman, (8:463) using five groups of subjects, he initiated a weight training program in one group to determine whether or not weight training tends to help increase speed when used as a supplementary program. In his conclusions it was found that the weight training program did not improve running speed significantly more than the sprint training program. However, Dintiman did show that a difference in adjusted means of only 0.01 did prevent a significant difference at the .05 level. Using a combination of flexibility and weight training programs as a supplement to his sprint training program, he found that the running speed of the subjects using the supplementary program improved significantly more than the subjects using the sprint training alone. (8:463)

Rankin makes no mention of a weight training program used as a supplement for increasing speed or increasing leg strength. He feels that weight training should be used for upper body development. The upper body will develop more quickly that the lower body, and this gives a feeling of strength that will encourage lower body development. (15:19)

Breathing While Running

Related to running and of utmost importance is the breathing of the sprinter. Although there is a limited amount of research done on the methods of breathing best suited for the sprinter, one must bear in mind that the better the physical condition of the sprinter and the efficiency of the warm-up, the less the air requirement.

Many coaches recommend that the sprinter hold his breath for the full 100 yards, others recommend two breaths, one at sixty yards and the second at ninety yards, while still others recommend only one breath during the race and that occurring at eighty yards. (6:16) Some coaches, however, make no recommendations, leaving it up to the athletes.

Though authorities have reached no uniform decision on the best method of breathing, it is generally understood that proper breathing in sprinting plays an important role. In relation to breathing, the most important factor for consideration by the sprinter, or the coach of the sprinter, is that a sufficient amount of oxygen and that a sufficient amount of carbon dioxide must be eliminated to ward off fatigue as long as possible.

Forceful breathing for two or three minutes before getting to the marks is a procedure followed by many sprinters. Scientific evidence supports this procedure since this practice reduces the carbon dioxide in the blood and postpones the tendency toward labored breathing. (2:75) The breathing habit of the sprinter in the "set" position is involuntary. It has been demonstrated that when the sprinter is in the "on the mark" position, his breathing is normal. As the second command of "get set" is given, the sprinter takes a deep breath and holds it until the gun is fired. The breathing habits of the sprinter in the "set" position is similar to the golfer concentrating on a putt or a marksman aiming at the target. (2:75)

It is the feeling of this researcher that one breath at eighty yards would be the most beneficial. Stein (17:74) noted from experience that as the sprinter nears the finish line, at about eighty yards from the start, a conscious breath seemed to give him an added boost for an extra spurt for the tape. Care must be taken so that this breath doesn't retard the running action through an unnatural raising of the head. (17:74)

Types of Starts

The start is of great importance to the sprinter in reducing his time. Any coach should help a sprinter to choose the most appropriate start for that individual's build, leg drive, center of gravity, and thrust.

This researcher pointed out to each group used in this study that the medium start appeared to be the most favorable according to some test results. Some results of tests revealed that the bunch start gave the second best times and that the elongated starting position seemed to be the slowest.

In a study carried out by Sigerseth and Grinaker (16:599), twenty-eight members of a track and field class for male physical education majors at the University of Oregon were timed from the bunch, medium, and elongated starting positions for distances of 10, 20, 30, 40, and 50 yards. Every distance was sprinted in less time from the medium starting position than from either the bunch or the elongated positions. These differences were significant, however, only when the times from medium and elongated starts for distances of 10, 20, 30, and 50 yards were compared. A significantly shorter mean time was also required to sprint thirty yards from the bunch than from the elongated starting positions. (16:599)

Whatever the starting position, the following factors must be considered at the start, according to Bresnahan and Tuttle (3:71-73-74):

1. The Position of the Feet---the distance of the feet from the starting line is determined by the height of the runner and the type of start. The width of the space between the feet is determined by the width of the hips.

2. The Position of the Hips---the closer the feet on the start the higher the hips. In the bunch start the hips are about 25° higher than the shoulders, and the longer the starting position the lower the hips.

3. The Position of the Hands and Arms---the hands are placed on the starting line with the weight on the thumb and fingers and the arms fully extended, not bent, when "on the mark".

4. The Position of the Head and Eyes---with the head in line with the body, and according to type of start, the runner looks straight ahead as far as is consistent with his body position. Usually the sprinter sees about two feet from the starting line and watches his first two or three steps to keep from popping up.

From the starting position the sprinter begins to accelerate his speed at a maximum of thrust.

Research shows that the thrust on the back block is initially greater than on the front block, but that the total force exerted on the front block is greater because of a longer application of power, pushing the sprinter further away from the blocks. (17:14)

> When the space between the feet increases, the amount of force of the back foot increases. As a matter of general information, it might be stated that the average sprinter exerts a force represented as 195 pounds with the front foot. When the feet are close together, as in the bunch start, the average sprinter exerts a pressure of 150 pounds with the back foot. As the foot spacing is increased, the pressure exerted by the back foot increases, reaching 195 pounds in the medium position and 210 pounds in the elongated start. (2:76)

In commencing the start of the sprinter, the action of the arms is of great significance in overcoming inertia and developing the thrust of the body, according to Bresnahan and Tuttle. (3:438) Arm movement plays an important part in the entire race. At the gun, the sprinter's left arm is thrown straight ahead, with the right foot back, and only a slight bend at the elbow; the right arm is moved straight back. The upward chopping of the arms at the start tends to straighten the body and is, therefore, used after the runner is in full stride. (3:438)

<u>Action of Arms</u>

Concentration on the arm movement at the start is of great importance. Bresnahan and Tuttle (3:438) have their athletes concentrate on the forward thrust of the left arm while the right foot is back.

Stein (17:13-14) has another conviction. Using Newton's Law as a basis, Stein experimented by having the runners concentrate on the forward thrust of the right arm rather than the forward thrust of the left arm. This remedied the problem of the lost rear arm motion, without affecting the good driving position of the front arm. This procedure is being used successfully for all starts, sprints and hurdles alike. When the runners come to the "set" position, they think of front-foot drive and rear-arm thrust. (17:13-14)

Another difference involves the first movements of the arms as they thrust into action. Many coaches will instruct the left-footed starter, (the left foot forward) to drive on the front foot and to shoot the left arm forward, giving little thought to the action of the right arm. The counter movement of the arms is based on Newton's Third Law of Motion---for every action there is an equal and opposite reaction. Many boys get started in good position with the forward arm, but have trouble with the other arm.

After the runner clears the blocks, he is concerned with reaching his maximum running speed as quickly as possible without sacrificing velocity. Some runners reach their "pick-up" by taking short and unnatural steps. It is recommended that the first step be a natural one which allows an effective drive and aids in good body position. (17:14)

Running Strides

Running strides of any sprinter determine the speed at which he can run the one hundred yard dash. Strides of every sprinter vary depending on the height, weight and body position of the sprinter. The stride begins with the firing of the starter's gun and is broken down into three classifications. The starting stride, the transitional stride and the full-speed stride. (2:78-82)

The starting stride begins when the right foot first applies force against the back block and ends the instant before it leaves the ground the second time.

Forward propulsion of the first stride is initiated by the back leg, and is followed very quickly (approximately 0.01 sec.) by the driving action of the front leg. The front leg power of the forward propulsion of the body lasts considerably longer than the back leg force (more than twice as long for the average sprinter). At the conclusion of the push-off the back leg starts forward, applying pressure on the left leg and swinging the right hip backward, which is compensated for by the swinging force of the arms. The right foot continues forward and is placed on the ground, the knee forming almost a right angle as the left leg is leaving its support. The left leg then continues forward with a knee lift as did the right leg.

The point to strongly emphasize is that during the first two strides, terrific force must be applied by both arms. The power in the leg drive determines the acceleration. (2:78-79)

Realizing the amount of leg force necessary in the start, another point brought out by Myers and Hacker, (14:27) would be helpful to the sprinter.

"Careful testing indicates that a sprinter will gain maximum speed off his marks if he cuts his first two strides down to a distance of from two feet nine inches to two feet eleven inches. The stride is measured from the rear block instead of on the starting line." (14:27)

As the sprinter picks up speed, his stride is lengthened by three or four inches until he reaches his normal stride. This phase from the start to the full-speed stride is referred to as the transitional stride. (14:27)

The average sprinter usually has a transitional stride for a distance of from ten to fifteen yards from the starting line and usually requires from six to nine strides. As previously mentioned the stride lengthens progressively during the transitional period, but one must remember that the trunk is beginning to straighten to a more erect position.

In this section of the sprint the principle involved is that since the trunk lean is greater, the center of weight is closer to the ground, and the strides are shorter than the full-speed stride. At this phase of the sprint, the bend of the knee of the recovery leg, when the foot contacts the track, varies with the athlete (the bend is greatest in the first stride and becomes less and less until it becomes constant at full speed). From the start of the sprint through the period of acceleration, the driving leg executes a terrific backward thrust by extending both the knee and ankle. To this force a powerful backward extension of the hip is added. As full speed is approached and the knee becomes straighter as the foot hits the ground, the backward knee thrust is reduced, almost vanishing as an effective propelling force. (2:82)

When the sprinter ceases to accelerate or further increase his speed, he has reached his full-speed stride. As full speed is attained, there is no further change in trunk angle, and the strides become uniform in length. (2:82)

A stride is the distance between the toe of the right foot and the toe of the left foot. To explain the full-speed stride one must consider the complete cycle (two steps). The cycle begins when the right foot leaves the ground and ends when it leaves the ground a second time. The full-speed cycle is divided into the recovery and driving phases. (2:83)

During the recovery phase, with the knee flexed and the foot under the buttock, the leg is brought forward as expeditiously as possible with the minimum waste of energy, allowing it to be placed in the optimum position.

From this position, as the toe touches the ground the driving phase begins. As the driving force of the leg is applied, the knee is very slightly bent and the foot lowers until the heel almost hits the ground. A strong thrust of the foot is accompanied by a powerful backward sweep of the whole right leg, which is responsible for the forward propulsion of the body. Power continues to be applied and the body is propelled forward as long as the toe of the right foot contacts the ground. (2:83)

There is only slight vertical bounding due to the straightening of the driving leg, which moves the body up as it goes forward. (2:83)

During the full-speed stride the sprinter must learn to maintain acceleration throughout the entire race since he reaches his maximum speed so soon. Cooper (6:16) stated that every sprinter has a maximum leg speed which he must not try to exceed, or he will "tie-up" or break stride. (6:16)

It is generally understood that most coaches teach an athlete to "run on his toes" and not his heels.

According to Sylvia (18:15), the body is driven forward with maximum force or leverage only if the heel has touched the track without reservation so that a maximum extension of the ankle and toe can be made as the ball of the foot leaves the track. The principle is that a muscle is strongest when under stretch. Consequently, it is evident that any running, especially sprinting, which does not always allow the heel to touch the track with each step, robs the runner of his maximum leverage. (18:15)

Running Technique at the Finish

The finish of any race is the paramount objective of that race. To the sprinter the finish is determined through much practice and concentration. The finish is practiced just as any other aspect of sprinting might be. The controlled "lean at the tape" is a general accepted finish, which does not reduce the runner's speed.

Assuming that the runner has reached maximum speed at about fifteen yards, and has maintained this speed throughout the race, the finish consists of a continuation of full-speed strides to a point beyond the finish tape. At top speed the sprinter cannot make any body movement which will increase his speed at the finish line. Anyone who can use a lunge, jump, or turn at the finish line and increase his speed has not been running at top speed anyway. (2:85)

Other important aspects of the finish include not only striding through the tape, but a controlled lean at the tape, knowledge of the rules, and how a finish is judged.

Since the sprint produces so many close finishes it is absolutely essential that the runner practice a conscientious and scientific finish. Two devices are recommended and practiced to make the finish more exact. One is the "preliminary breath at about eighty yards" and the other is " a conscious lean at the tape".

Because the torso of the runner determines the winner of the race, it is this portion of the body one must work on for the faster finish. About two or three yards from the tape, the runner should consciously drive the torso forward, and at the same time throw the arms back. A slip on timing will hinder the speed; therefore, practice is necessary to be able to "lean at the tape" at the exact fraction of a second. (17:74)

<u>Training Programs to Improve Speed and Performance</u>

Most of the programs used to improve speed have been used as a supplement to the conventional training programs. The training programs used have varied from three to six days per week for a period of from three to six months.

The point of concern here is the effects of weight training on speed. This researcher feels that muscle hypertrophy will tend to slow the individual's running speed and that one improves by doing. Studies have been made with weight lifting or heavy systematic resistance to determine speed reaction of muscles, strength, speed movement and endurance. On the other hand, it is also believed that in order to increase the strength of muscles it is necessary to exercise them against gradually increasing resistance.

One of the most common criticisms of the use of weight training has been that it results in muscle boundness. Muscle boundness is the impaired speed of movement. (10:23)

Many people feel that muscle boundness will develop a reduction in reaction time in certain sports. With this in mind Zorbas and Karpovich (21:145-148), decided to test two groups of subjects in this area.

Using six hundred subjects, the speed of the rotary movement of the arm was tested. Half the subjects trained with weights while the other half did not. Their results showed that the weight lifters had faster rotary movements of the arms. The difference was significant at the .01 level of confidence. (21:145-148)

Capen (5:83-93) performed an interesting study which contributes to the use of weight training as a method of conditioning. His primary concerns were the effects of weight training in the areas of power, strength, and endurance. Using two groups, the experimental group trained with weights while the control group went through a strenuous conditioning program. The results showed that weight training was as effective as the conditioning program in relation to muscular and circulorespiratory endurance and provided a greater degree of muscular improvement. (5:83-93)

Kusinitz and Keeney (12:294-301) investigated the effects of weight training on junior high boys. They used anthropometric measurements, muscular strength, flexibility, speed and agility, and circulorespiratory endurance. After eight weeks, the experimental group had made significant gains in two anthropometric measures, muscular strength and flexibility. There was no significant difference between the groups in regard to speed and agility and the results were uncertain for the circulorespiratory tests. During the study the control group participated in the regular physical education program. No harmful effects were noted at the end of the study. (12:294-301)

Another investigation to determine the effects of weight training on speed of muscles was made by Wilken (20:361-369). Wilken used three groups of subjects. One experimental group had no previous weight training experience, the other was selected from the university weight lifting team, while the control group was taken from swimming and golf classes.

It was found that weight training over a period of one semester did not slow up arm movements. In the case of the weight lifting team, it was found that they were not muscle bound in the sense of impaired speed. Additional findings indicated that a semester of weight training did not increase speed more than participating in golf or swimming and that weight training may improve muscular endurance. (20:361-369)

Using twenty-six subjects, thirteen in weight training and thirteen in regular physical education classes, Mosley and Chudet (13:1) tested elbow and hip extension, hip flexion with the knee bent and extended, knee and shoulder flexion, and shoulder extension. Measurements were taken of height and weight, and of the girth of the biceps, chest, thighs, and calves. In addition, they tested the subject's back lift, leg lift, and grip strength.

It was found at the end of six months that weight training did not appear to affect over-all body development, but it did cause marked increases in the upper arm girth and grip strength. The program of heavy resistance exercises in which the subjects participated did not result in an over-all reduction in range of movement of the joints throughout the body.

The authors felt it was feasible to surmise that weight training could effect a reduction or increase in the range of movement depending upon the training routine and the manner in which the exercises are executed. (13:1)

Only a limited amount of information can be found on the effects of weight lifting on one's running speed; however, this review of literature poses some good questions on the validity of weight training. One might assume that if increased speed of the arm rotation can be obtained through weight training, so can the running speed. On the other hand, two surveys show no increase in speed after using weight training programs.

It is the belief of this researcher that running speed is innate, and to reach the maximum speed potential, one must run dedicated to reaching this maximum speed. With this running force, the leg strength will develop.

CHAPTER III

PROCEDURE

The purpose of this study was to determine if a weight training program, used as a supplementary program to a conventional method of sprint training, would improve the speed of sprinters.

Selection of Subjects

The subjects used in this study were ninth grade boys representing two physical education classes at Ledford High School, Davidson County, North Carolina. Permission to use the students for the study was granted by the Superintendent of Davidson County Schools and the Principal of Ledford High School.

A total of seventy-one boys from two classes, thirty-eight in one class and thirty-three in the other, were selected as subjects. According to physical examinations by the family doctors of the subjects, and the medical histories on the accumulative records, all subjects were found to be physically able to participate in the study.

During the program three subjects were dropped. One subject dropped out of school and two moved to other schools.

Grouping of Subjects

The subjects used in this study had no prior background in sprinting techniques and fundamentals. No subject had ever been on a track team nor had any of them ever been taught the proper methods of starting, running or finishing.

The fifth period class was designated as the experimental group (A) and the sixth period class was designated as the control group (B). All subjects were required to run the one hundred yard dash with individual times being recorded and mean times for the two groups being calculated. Group A (experimental) had a mean score of 14.80 seconds while group B (control) had a mean score of 15.01 seconds, a difference of .21 seconds, on the original timed-run.

Equipment

No special equipment was needed for this study. The equipment used included: three sets of adjustable starting blocks, one blank pistol and blanks, a stop watch, and the portion of the track marked off for the one hundred yard dash.

All subjects ran the same lane and the same direction each day and each subject wore tennis shoes instead of track shoes.

The Training Program

While reviewing studies of isometric training programs, flexibility programs, various weight training programs, a conventional sprint training program and various combinations of these programs, it was noted that no reports indicated a significance of increased speed at the .05 level. Therefore, a variety of program combinations were used in developing the training programs used in this study. Many of the exercises and warm-up drills are found in various materials, but most of the exercises used herein were found in the materials of Bresnahan (1:85-92) and Dintiman (8:456-463). Changes were made in the pre-season drills and the competitive-season drills, but the late competitive-season drills were not used.

A chart was developed to record each timed-run of each individual and a line graph was used to illustrate daily mean scores. Each subject was given a graph with his time recorded daily to enable him to observe his own progress.

The program began in September which allowed an adequate amount of time for good weather. The first five days were used as an orientation period to expose the subjects to the study and its purpose. During that week the researcher instructed both groups one hour per day on the proper techniques and fundamentals of sprinting.

All subjects were given an opportunity to experiment with and to choose their own methods of starting, being instructed in the bunch, medium and elongated starting positions. It was pointed out to each group that tests proved the medium start best in reducing starting times with the bunch start showing the second best times and the elongated starts showing the longest times.

The writer, in an attempt to improve the acceleration from the start, informed the two groups that a start from a position of equilibrium with the center of gravity just within his base was important. In the start the sprinter must overcome inertia and because of the great resistance at the first forward movement, it is of great importance that maximum power be executed to assure maximum acceleration. As the sprinter is driving from the starting blocks the body should be at approximately forty-five degrees from the ground. This angle is measured from the toe and heel of the rear foot, and once he commences to move, this position allows the legs to extend with greater force, therefore increasing acceleration. (18:14)

In the starting position also, the subjects were taught to place their weight evenly between the hands and feet for the best starts. Both groups were taught the importance of breathing at the starting line. Each subject took two deep breaths before taking his starting position and then relaxed until the command of "get set" was given, at which time a deep breath was taken and held until another was needed down the track, usually at about eighty yards. Each subject learned the importance of concentrating on the start and all movements involved, to insure a more consistent start. The two groups learned the importance of leg thrust and how to execute this leg force with a quick thrust from the blocks.

Instruction continued to the running strides with the emphasis being placed on the importance of the driving force of the legs, which is the power of forward thrust of the body weight during the stride. The importance of maintaining body balance, and using a naturally developed motion to overcome inertia was emphasized to the subjects. The phases of striding were described to the subjects, breaking them down into the starting stride, the transitional stride or the "pick-up", and the top speed stride. (2:78-82)

The researcher chose to use the "preliminary breath" at about eighty yards and the idea of "running through the tape" as the type of finish necessary for consistent results. (2:74) Each subject practiced this type of finish and was directed never to turn away, lunge or jump at the finish line, since a reduction of speed occurs. (2:85)

Following the orientation period, the pre-season sprint training program was begun. Both groups of subjects participated in the pre-season drills. To eliminate pulled muscles, especially the hamstrings, and to aviod shin-splints, the following program was executed:

1. Jog fifty yards and walk ten yards. Repeat five times.

2. Chin-up five times. Add one every other day if possible.

3. Do fifteen push-ups. Add two each day.

4. Leg stretching exercise for three minutes.
   a. trunk bending, touching the ground with the fingers while keeping the knees stiff.
   b. vigorous kicking of the leg backward and forward, alternately.
   c. alternately pulling the knee up against the chest.

5. Mountain climb, in the front-leaning -rest position, pull one leg under the chest allowing that leg to support the weight while stretching the other, then alternate legs.

6. Using three sets of adjustable starting blocks, three subjects took four or five trial starts, adjusting the blocks to their own liking. The researcher supervising the starts gave the commands.

7. Simulating an official start, each subject took a trial run for thirty yards when the gun was fired.

8. Practice ended with a jog of three hundred yards, increasing the speed toward the end so that the last fifty yards were run at nine-tenths speed. (2:90-91)

This program was used for two weeks and each subject was supervised and aided in any way possible to correct any errors in the fundamental process of running. Care was taken that each subject carefully attended to all phases of running to enable him to participate in the timed-runs without any injury.

The two groups learned that everyone cannot be a champion sprinter; therefore, the most important thing was to challenge one's self continuously to improve one's own timed-run.

On the last day of the two weeks of pre-season training, the groups were given time for a brief conference to discuss any problem that might have occurred and the instructor outlined the program for the charting of the actual timed-runs. The fifth period class, group A (experimental), had the supplementary weight training program outlined during this time allotted for the conference.

Group A was instructed to participate daily in the manner that had been described and was asked to keep a private record of the amount of weight used.

In September, 1967, the first day of actual timed-runs began. A daily sprint training program was carried out before any timed-runs were recorded. This daily program was to continue for five days per week for a period of six weeks.

Both groups participated in the following programs:

1. Jog fifty yards and walk ten yards. Repeat four times.
2. Do ten chin-ups on the horizontal bar.
3. Do twenty-five push-ups.
4. Leg stretching exercise.
   a. trunk bending-touching the ground with the fingers while keeping the knees stiff.
   b. mountain climb-in the front-leaning -rest position, alternately bringing one leg under the chest and supporting the body weight, while stretching the other.
   c. vigorous kicking of leg backward and forward, alternately.
   d. alternately pulling the knees against the chest. fifteen repetitions.
5. Using one of three sets of adjustable starting blocks,

each subject took three practice starts for effectiveness. (2:90)

6. Each subject ran the one hundred yard dash and had his time recorded daily by the researcher.

7. Daily training ended with a jog of three hundred yards.

Both groups carried out identical programs of sprint training. The experimental group (A), however, supplemented its program with a weight training program designed to increase leg strength, which began the first day of timed-runs and continued for the remainder of the study.

The experimental group (A) carried out its supplementary program with weights as follows:

1. Dead-lift---with bar bell lying on the floor the subject would lift the weight straight up in front of the body until it was at the top of the arm's reach over the head.

2. Heel-raise---with the bar bell balanced on the shoulders and behind the neck, the subject would grasp the bar and raise the heels off the floor as high as possible, then return.

3. Straddle-lift---having the bar bell lying on the floor, the subject would straddle the bar, perpendicularly, and with the right hand behind the body and the left hand in front of the body, squat, grasp the bar and lift the weight with the force of the legs to the straddle.

4. Three-quarter squat---with the bar bell held on the shoulders and behind the neck, the subjects would squat three-fourths of the distance between the buttocks and the heel, keeping the back straight.

The bar bells weighed twenty-five pounds the first week of training and each subject did ten repetitions of each exercise. At the beginning of the second week of recorded one hundred yard dashes, any subject having any degree of difficulty with ten repetitions with twenty-five pounds was to continue until he could perform the exercises without undue strain. None had any trouble; therefore the progressive resistance method was employed and when the subject could perform twelve repetitions of the four exercises with thirty-five pounds of weight he would add ten more pounds of weight and return to eight repetitions. (8:459)

Two student aids were used to supervise the weight training program while the researcher was on the track timing the runners. An assistant instructor was used to fire the gun for starts. The student aids were senior athletes and good leaders and were well acquainted with the weight program.

Statistical Procedures

A "t"-test, as described by Ferguson (9:169-171), was selected to determine if there was a significant difference between the means of the two groups at the beginning of the training programs. A frequency polygon, utilizing daily mean times for each group, was prepared to compare the two groups and the day to day changes made by each group. Since no significant difference between the means was found, the same test was applied to the means of the final times. Additional "t" tests for correlated samples (9:169-171) were used for each group to see if there were significant changes between the means of the first timed-runs and the last timed-runs.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

A line graph used to chart the daily mean scores, as seen on page 30 (Figure 1), gives a visible observation of the two groups being studied and will show the differences in means during this study.

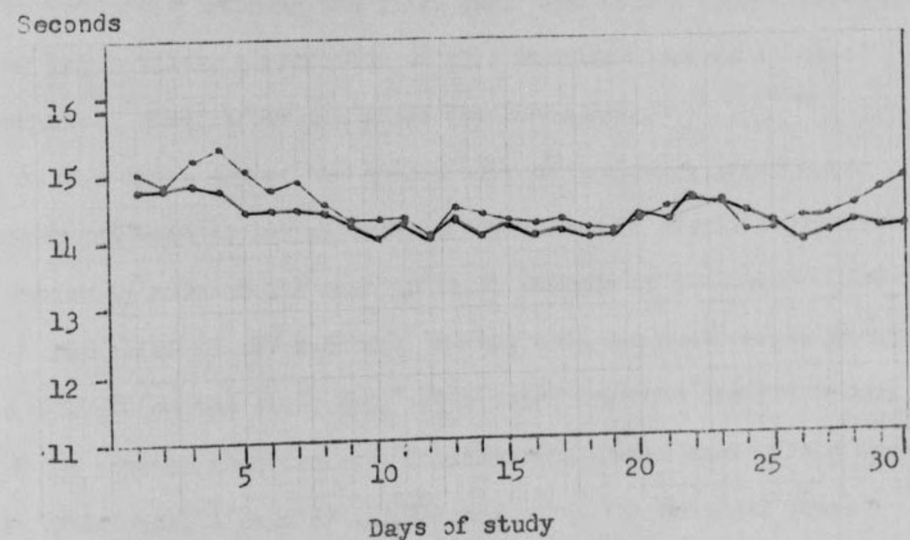
During the first week of training there was a great difference in the fluctuation of mean scores of the two groups. On the first day of timed-runs the mean score for the control group (B) was 15.01 seconds and the mean score for the experimental group (A) was 14.80 seconds. Group A (experimental) showed very little increase in the mean time from the original mean score through the fourth day. In fact, the mean score had increased only .01 seconds from the original mean, and .06 seconds on the second and third days, respectively. Group B (control) however, had a reduction in mean times of .06 seconds from the original mean on the second day and an increase of .21 seconds the third day from the original mean.

On the fourth day, however, the experimental group had a mean time of 14.80 seconds, the same as the original mean, and had reduced the mean time .35 seconds (14.45) on the fifth day.

Group B on the fourth day had an increased time of 15.40 seconds, .39 seconds greater than the original mean and had a mean time of 15.07 seconds on the fifth day, .06 seconds greater than the original mean. There was a reduction in mean times for the experimental group for the first week and an increase in the mean times for the control

FIGURE 1

GRAPH OF DAILY MEANS
OF BOTH GROUPS



Control Group ________

Experimental Group ________

group.

These differences could very possibly be due to the soreness of muscles obtained during the first series of timed-runs. The control group (B) experienced only conventional training. The experimental group (A) began lifting weights and supplementing the conventional training the first day. Due to the hyperextension of the leg muscles, a reduction of sore muscles appeared in the experimental group after the first few timed-runs.

On the first day of the second week of training, group A had an increased mean of .04 seconds (14.49) from the previous Friday, but gradually reduced its mean to 14.01 seconds on the tenth day, a reduction of .79 seconds. During this two week period group B had a 14.80 on the sixth day, .27 seconds les than the fifth day, and after several fluctuations, finished the second week with a mean of 14.37 seconds, a drop of .67 seconds below the original mean.

After two full weeks of the program, the experimental group (A) appeared to be reducing their mean times much more rapidly than the control group (B). During this period of time group A reached a peak faster than group B. (Figure 1, page 30)

The same pattern developed during the third week; however, there was less decrease in means than noted during the first two weeks. During the fourteenth day group A recorded its lowest mean time (14.06 seconds). On the next day the mean increased to 14.25 seconds. This was only .03 seconds lower than the time at the beginning of the week.

On the thirteenth day both groups ran with strong winds in their faces, which probably increased their running times.

After three weeks of the program it appeared that the experimental group (A) had reached a peak at which it would level off and remain relatively constant. Group B (control) seemed to be gradually progressing and improving.

The original means showed a difference of .21 seconds between the two groups, with group A lower; however, the difference of mean scored changed appreciably after three weeks. At the end of the first week and at the end of the second week the difference between means was .62 seconds and .36 seconds, respectively, with group A still lower in both cases. By the end of the third week of training the difference between the means was only .04 seconds. Although the mean of group A was still lower, group B had made steady improvement.

The fourth week of the program showed a leveling off by both groups with group B gradually overtaking group A. On the third day of that week (18th day), group A had a mean of 14.00 seconds, the second lowest daily mean recorded by either group throughout the entire training program. Group B steadily reduced the mean difference until the twentieth day, when group B had a mean time of 14.25 seconds, .08 seconds lower than group A's 14.33 seconds.

Even though the mean times were not the lowest recorded, there was a difference of .08 seconds which showed a progression by the control group (B). It appeared at this point that the experimental group had begun to regress to a greater extent than the control group.

Before the fifth week of training could begin, time was allowed for the rain to subside and a day was given for the track to dry. Since the mean times were high the first three days of the week, one may reasonably assume that the track was slow and that the wind on the 22nd day, which was in the sprinter's face, may have affected the running speeds. On the twenty-fifth day, however, the sprinters ran with strong winds to their backs, probably aiding them in reducing their times. Running conditions remained the same for both groups.

The fifth week began with the experimental group having a mean score .23 seconds lower than the control group, allowing the experimental group to regain the lead. Group B attained the lowest daily mean, 14.09 seconds, during the week however.

At the end of five weeks of training it appeared that each group had reached a plateau. There was a very small difference between means, with group B having the lower mean by .09 seconds. It appeared too, that both groups had reached their running peaks.

Beginning on the first day of the sixth week of the program a drastic change took place. The twenty-sixth day saw the experimental group improve their mean time to an all-time low of 13.94 seconds, .86 seconds lower than the original mean and .06 seconds lower than their previous lowest mean. Group B, on the other hand, increased its mean time from the previous day .17 seconds, but was still lower than the original mean at 14.28 seconds.

The following days of the study saw group A remain fairly consistent with means of 14.00 seconds on the twenty-seventh day, 14.20 seconds on the twenty-eighth day, and 14. 15 seconds and 14.16 seconds on the twenty-ninth and thirtieth days, giving a picture of consistency. Group B continued to increase its mean time each day of the sixth week. The means for the control group increased from 14.28 seconds on the twenty-sixth day to 14.83 seconds on the thirtieth day.

The drastic changes in the mean times of group B during the final week are not completely clear, unless the group had lost some motivation since they had caught and surpassed the experimental group. It is possible that a lack of extra training could have affected the runner's speed, not allowing him to remain consistent for very long periods. Too, there may have been a lack of interest shown by group B due to the routine manner in which the training took place.

The consistency of mean times of group A may be due to a competitive spirit developed through the lifting of weights, or a desire to maintain its prestige as the leader in mean scores of the two groups.

A second summary of mean differences should be considered at this point. Since the mean differences for the first, second, and third weeks were .62 seconds, .36 seconds, and .04 seconds in favor of the experimental group (A), a progression is visible when these differences are compared with the .21 seconds difference from the original means. (See Table I)

TABLE I

A WEEKLY ANALYSIS OF MEANS AND DIFFERENCES OF TWO GROUPS OF SPRINTERS

WEEK	MEAN TIMES A Exp.	MEAN TIMES B Cont.	MEAN DIFFERENCES IN SECONDS	LOW GROUP
Orig.	14.80	15.01	.21	A
1	14.45	15.07	.62	A
2	14.01	14.37	.36	A
3	14.25	14.29	.04	A
4	14.33	14.25	.08	B
5	14.20	14.11	.09	B
6	14.16	14.83	.67	A

A comparison of the progress made by the two groups during the training period seems to indicate that weight training helped the sprinters to reach their peak of performance sooner than the non-weight lifters. In addition, weight lifting seemed to help the sprinters to hold this peak, or remain consistent, for a longer period of time. The non-weight lifting sprinters did, however, reach a peak through running and applying a conventional sprint training program, but did not appear to hold this peak quite as long.

It is the feeling of this researcher that this study would benefit the sprinter and the coach of the sprinter who might be concerned with reaching a maximum running speed as soon as possible, depending on the amount of time allotted for the pre-season training before competition. The length of the competitive season is important also, in that weight training might be included when the season may last more than five weeks.

During the study, group A (experimental) had no great increases in mean times, but group B (control) showed considerable increases on three different occasions.

<u>Significance of the Difference Between Means</u>

The exact statistical procedure for treating the data was selected after the means of the initial sprint times for the two groups were subjected to a "t" test for independent samples (9:167-169) to determine if there were a significant difference between the two groups in so far as 100 yard sprint time was concerned. The "t" of .58 was far below the 1.998 needed for significance at the .05 level of confidence (Table II, page 38). Therefore, the groups were considered to be equated in relation to sprint times. The same test for independent samples was selected as the appropriate statistical procedure for treatment of the mean times recorded the final testing date. The data revealed a "t" of 5.42 which was significant at the .05 level (Table III, page 39). To further investigate the changes in sprint times after the six week training programs, "t" tests for correlated samples (9:169-171) were used to determine if the changes were significant within each group. The difference between the sprint time recorded the first day and last day of the training program was calculated for each subject in the control group. The test for correlated samples revealed no significant change at the .05 level of confidence (Table IV, page 40). These same procedures applied to the experimental group data resulted in a "t" of 5.72. This was well above the 2.030 necessary for significance at the .05 level (Table IV, page 40). These tests substantiated the test of the difference between the final means of the two groups. It can be assumed, therefore, that there was a significant difference between the training programs.

TABLE II

SIGNIFICANCE OF THE DIFFERENCE OF INITIAL MEAN SPRINT TIMES BETWEEN GROUPS

Group	Number	$\bar{X}$	S^2E	t
A	35	14.80	2.225	.58
B	33	15.01		

"t" .05 = 1.998 for N=66

TABLE III

SIGNIFICANCE OF THE DIFFERENCE OF FINAL MEAN SPRINT TIMES BETWEEN GROUPS

Group	Number	$\overline{X}$	S^2_E	t
A	35	14.16	2.10	5.42*
B	33	14.83		

* significant at .05 level of confidence

"t" .05 = 1.998 for N=66

TABLE IV

SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE INITIAL AND FINAL SPRINT TIMES FOR EACH GROUP

Group	Number	$\bar{X}$	$\bar{SD}$	t
A	35	.646	3.952	5.72*
B	33	.182	4.42	1.36

* significant at .05 level of confidence

"t" .05 = 2.030 for N=35

"t" .05 = 2.042 for N=33

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine if a weight training program, used as a supplementary program to a conventional sprint training program, would improve the speed of the sprinters.

Seventy-one ninth grade boys participated in the study. There were two groups, the experimental group (A) and the control group (B). Group A had thirty-eight boys while group B had only thirty-three boys. The study was carried out Monday through Friday of each week for a period of six weeks. The control group (B) performed only a designed program of sprint training, while the experimental group (A) used a supplementary program of weight training with the sprint training program.

The raw data of the means were treated statistically through a "t" test to determine if there were a significant difference between the means of the two groups. There was a significant difference at the .05 level of confidence.

From the results of this study it is concluded that weight training, when used as a supplement to sprint training, does increase the running speed of the sprinter.

The following recommendations are suggested for further study in this area:

1. A more homogeneous grouping of subjects should be utilized.
2. A consideration should be given to body builds, weight

and running strides.

3. A consideration should be given to subjects with athletic and non-athletic backgrounds.

4. A consideration should be given to the desire of the subject to be a sprinter.

5. A consideration should be given to a shorter period of training with fewer days.

6. One should concern himself with the possibility of a motivational problem.

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APPENDIX

APPENDIX A

MECHANICAL PRINCIPLES OF RUNNING

1. In accordance with the first law of motion, a body at rest remains at rest unless acted upon by a force. In running, the problem of overcoming inertia decreases as the level of speed is reached. It is greatest at the take-off, and least after acceleration ceases.
   a. The crouching start enables the runner to exert maximum horizontal force at the take-off by:
      1. Providing a horizontal resisting surface against which the foot can push.
      2. Putting the legs in a more horizontal position.
      3. Enabling the runner to use maximum hip, knee, and ankle extension in both legs.
   b. During acceleration, the horizontal component of the leg drive gradually diminishes until a level of speed is maintained, during which period it remains uniform. The period of acceleration is characterized by a gradual decrease in the forward inclination of the trunk, a lengthening of the stride (made possible by the raising of the center of gravity as the trunk becomes more erect), and decrease of the knee thrust, resulting from the gradual straightening of the knee at the moment of contact between the foot and the ground.

2. In accordance with the second law of motion, acceleration is directly proportional to the force producing it. Hence, the greater the power of the leg drive, the greater the acceleration of the runner.

3. In accordance with the third law of motion, every action has an equal and opposite reaction.

4. Since a long lever develops more speed at the end than does a short lever, the length of the leg during the driving phase of running should be as great as possible when speed is a consideration. This is achieved by full extension at the knee joint at the end of the driving phase.

5. The smaller the vertical component of force, the greater the horizontal or driving component.
   a. In the most efficient run, vertical movements of the center of gravity are reduced to a minimum.
   b. The vertical components of force should be just enough to counteract the downward pull of gravity, but not enough to

produce an unnecessary bounce in running.

6. The more completely the horizontal component of force is directed straight backward, the more it will contribute to the forward motion of the body. Lateral movements of the arms, legs, and trunk detract unnecessarily from forward propulsion. To assure forward motion of the body:
   a. The knees should be lifted directly forward-upward with the entire lower extremity kept in the sagittal plane. (Unathletic girls frequently run with a minimum knee lift and with an inward rotation of the thighs, the feet and lower legs being thrown out to the sides.)
   b. The arm swing should exactly counterbalance the twist of the pelvis and should not cause additional lateral motion.

7. Efficiency in running, as in any movement, requires the elimination of all unnecessary force.
   a. The shorter the lever, the less the force required to move it. By flexing the leg at the knee and carrying the heel high up under the hip in the recovery phase, the leg is moved more rapidly, as well as more economically.
   b. Internal resistance caused by the viscosity of the sarcolemma is reduced by warming-up activities.
   c. Internal resistance caused by tight muscles, fasciae and ligaments is reduced by systematic stretching exercises.
   d. Unnecessary force in the form of excessively rapid muscular contractions is eliminated by developing as long a stride as can be controlled.

APPENDIX B

RAW DATA OF SPRINT TIMES

Experimental Group (A)

Sprinters Below	Day number across 1	2	3	4	5	6	7	8	9	10	11	12
E-1	14.2	14.6	14.5	14.2	14.1	15.0	15.0	14.7	15.0	14.5	14.6	14.4
E-2	14.2	14.6	14.2	14.6	13.5	13.5	13.8	13.5	13.1	13.1	13.5	13.5
E-3	15.6	15.9	15.9	16.2	15.8	16.1	16.1	16.2	15.8	15.0	14.1	15.0
E-4	16.1	16.2	16.6	16.4	15.6	15.9	15.4	15.5	15.3	15.7	15.0	15.3
E-5	16.0	16.0	16.1	16.0	15.8	16.2	16.3	15.6	15.6	15.2	15.0	15.0
E-6	15.1	15.2	15.3	15.2	15.1	15.1	15.0	14.6	15.0	14.4	14.6	14.5
E-7	15.7	15.8	16.1	15.3	15.4	15.5	15.5	15.4	15.0	15.4	15.4	15.0
E-8	13.3	13.3	13.4	13.2	12.6	13.2	12.8	13.0	13.0	12.6	13.0	12.4
E-9	13.8	14.1	14.1	13.7	13.2	13.3	13.1	13.0	12.8	12.9	13.3	12.6
E-10	13.8	14.5	14.5	14.7	14.5	14.3	14.4	14.3	13.3	13.8	14.5	13.8
E-11	16.2	16.5	16.5	17.0	16.3	16.6	15.9	15.9	15.4	15.3	16.1	15.0
E-12	17.0	16.3	16.5	16.8	16.4	16.5	16.8	15.5	15.3	14.8	15.7	15.2
E-13	13.5	14.5	13.8	13.4	13.4	13.4	13.3	13.6	13.5	13.0	13.2	14.1
E-14	14.1	14.4	14.5	14.8	14.2	14.4	14.2	14.6	14.8	13.5	14.8	14.1
E-15	14.7	14.3	15.0	14.5	14.2	14.3	14.2	14.6	14.0	14.0	14.3	14.0
E-16	15.0	15.4	15.5	15.8	15.7	15.4	15.8	15.1	14.5	15.4	14.5	14.7
E-17	12.2	12.4	12.9	12.5	12.5	12.8	12.3	13.0	12.2	12.8	12.0	12.6
E-18	17.2	16.5	16.2	16.6	16.3	16.5	16.6	16.4	17.0	15.7	16.2	15.4
E-19	13.4	13.4	13.9	12.8	12.6	12.7	13.0	13.2	13.3	12.5	13.2	12.8
E-20	14.0	14.2	14.0	13.4	13.5	13.4	13.2	13.9	13.2	13.7	13.1	13.6
E-21	15.6	15.6	15.6	15.5	15.2	15.4	15.0	15.1	15.4	15.0	15.4	15.0
E-22	13.6	14.7	13.9	14.5	14.0	13.4	13.4	13.4	13.3	13.6	13.0	13.6
E-23	17.2	16.8	16.9	17.7	16.0	16.4	15.7	16.0	15.2	15.0	16.4	16.3
E-24	14.5	14.5	14.7	14.1	13.7	14.0	13.7	13.8	14.0	13.5	14.4	13.5
E-25	15.2	15.4	15.0	15.4	15.0	15.0	15.1	14.9	14.3	14.5	14.5	14.2
E-26	12.7	12.8	13.0	13.3	12.9	12.8	12.4	12.3	12.5	12.2	12.2	12.1
E-27	13.8	13.9	14.1	14.0	13.5	13.5	13.4	13.3	13.4	13.2	13.7	13.2
E-28	13.9	14.1	13.5	13.7	13.3	13.3	13.2	13.5	12.9	12.6	12.9	12.9
E-29	14.3	13.5	13.7	14.2	13.8	13.2	13.2	13.0	13.8	12.9	13.9	13.5
E-30	14.0	13.8	14.0	14.2	13.5	13.4	13.3	13.5	13.0	13.5	13.1	13.5
E-31	14.4	14.5	14.6	14.3	13.9	13.7	13.9	14.1	14.3	14.2	13.4	13.9
E-32	17.0	16.2	17.4	16.0	16.4	15.6	16.0	16.0	15.7	15.3	15.7	14.7
E-33	18.5	17.3	16.7	16.9	16.8	16.7	17.5	17.2	16.8	16.7	18.0	16.9
E-34	14.0	13.9	13.8	13.6	13.5	13.4	13.6	13.8	13.5	13.2	13.5	13.1
E-35	14.4	13.5	14.0	13.3	13.6	13.5	13.9	13.6	13.7	12.7	13.9	13.5
Daily Means	14.80	14.81	14.86	14.80	14.45	14.49	14.48	14.43	14.26	14.01	14.28	14.08

APPENDIX B

Experimental Group Times Continued From Page 49

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
15.2	13.9	13.9	13.9	13.5	14.0	13.8	13.8	14.2	13.2	13.5	13.5	13.5	13.9	13.5
13.8	13.2	13.3	13.0	15.5	12.9	13.0	13.4	12.7	13.9	13.4	13.4	13.0	12.8	13.0
16.1	15.5	15.2	15.5	15.4	14.9	14.7	15.1	15.2	16.0	16.2	15.8	15.3	14.7	14.8
15.1	14.8	15.5	14.6	14.6	14.8	15.3	15.1	15.2	15.4	16.0	15.2	14.7	14.7	13.3
14.8	15.0	15.0	15.0	15.7	14.8	15.3	15.4	15.8	16.0	17.0	15.6	15.0	14.5	16.1
14.3	14.4	14.4	14.9	14.5	15.3	15.3	16.2	15.0	14.0	14.3	15.4	15.5	14.3	14.7
15.5	15.0	14.9	15.3	15.5	15.0	14.6	14.9	14.9	15.5	16.0	15.2	15.3	14.0	14.4
13.1	12.7	12.9	12.5	12.5	12.6	12.5	13.0	12.8	13.3	13.0	13.0	12.6	12.4	12.6
13.0	13.1	13.3	12.7	13.0	12.9	12.7	13.3	13.0	13.6	13.6	13.3	13.0	12.7	12.8
14.0	13.2	14.6	13.9	13.8	14.5	14.1	14.1	13.9	13.8	13.5	13.9	13.5	13.5	13.0
15.5	15.3	15.6	15.3	16.4	15.7	15.1	15.4	15.3	15.5	15.6	15.8	15.3	14.8	15.1
15.8	15.5	15.9	15.3	15.3	15.0	15.5	15.9	15.8	16.0	16.0	16.3	16.6	15.2	15.4
14.5	13.5	14.0	13.5	14.0	13.6	13.6	13.9	14.2	14.0	13.9	13.9	13.8	13.8	13.6
14.9	14.3	15.0	14.5	14.7	14.7	14.3	15.6	14.2	13.9	14.1	15.0	14.6	14.0	13.9
13.8	14.2	14.3	14.0	14.2	14.3	14.3	15.2	14.2	14.1	13.8	14.9	14.5	14.5	13.0
14.6	15.0	14.3	14.7	14.9	14.5	15.3	14.7	14.3	15.0	14.7	15.5	15.9	15.0	14.7
12.2	12.0	12.5	13.2	11.8	11.6	11.8	12.0	12.2	12.0	11.8	11.9	12.2	12.5	12.5
16.7	15.7	16.5	15.8	15.4	15.5	15.8	16.5	16.0	16.4	18.2	16.8	16.8	16.0	16.1
13.4	12.8	12.8	12.5	12.7	12.7	12.7	13.4	13.5	13.3	12.7	12.2	12.1	13.2	13.0
13.3	13.0	13.2	13.4	13.6	13.2	13.1	12.8	12.9	13.4	13.0	13.5	13.6	12.8	13.2
15.5	15.0	15.4	14.9	15.0	14.4	14.6	14.8	15.2	15.4	16.0	15.5	15.6	14.6	14.7
12.7	13.2	13.1	13.0	12.7	12.9	12.8	13.0	13.1	13.6	13.4	13.0	12.8	12.7	12.9
16.5	16.2	16.6	15.7	15.7	16.0	16.1	15.8	16.0	18.1	16.1	15.6	16.7	17.3	15.8
14.0	14.4	13.0	13.6	13.8	14.1	14.4	14.3	14.5	15.0	14.4	14.1	13.6	14.2	14.1
13.9	14.4	14.5	14.2	14.0	14.3	14.9	15.4	14.7	14.5	14.3	14.6	14.3	14.2	15.0
12.9	12.5	12.8	12.4	12.0	12.2	11.8	12.2	12.0	12.6	12.8	12.2	12.1	12.1	12.0
13.6	13.4	13.3	12.9	12.9	13.3	13.3	13.5	14.3	13.3	13.3	13.5	12.5	13.0	13.0
13.3	12.5	12.6	12.7	12.6	12.3	12.2	12.4	12.5	13.2	13.2	13.0	12.6	12.5	12.6
13.7	13.2	13.5	13.5	13.2	12.8	13.1	13.5	13.1	13.5	13.8	13.5	13.4	13.3	13.2
13.0	13.1	13.0	13.1	13.1	13.7	14.5	13.5	13.2	12.8	12.8	13.5	13.5	12.9	13.2
13.5	13.5	13.7	13.1	13.7	13.5	13.5	13.5	14.5	14.4	13.6	14.0	13.5	13.3	13.7
15.7	15.2	15.5	15.3	16.0	15.1	15.0	15.2	15.6	16.5	16.7	15.7	15.5	15.0	15.1
17.2	17.1	18.0	17.7	17.5	16.6	17.1	18.4	17.0	18.0	19.0	18.1	19.0	16.8	18.3
13.5	13.5	13.5	13.2	13.4	12.9	13.3	13.3	13.5	13.4	13.8	13.5	13.3	13.2	13.2
14.0	12.9	13.3	13.6	14.0	13.0	13.5	13.8	13.5	13.6	14.6	14.0	12.2	13.6	14.2
14.36	14.06	14.25	14.06	14.17	14.00	14.08	14.33	14.23	14.49	14.51	14.39	14.20	13.94	14.00

APPENDIX B

Experimental Group Times From Page 50

28	29	30
14.0	14.0	14.3
13.5	13.5	12.9
15.4	13.6	14.5
14.0	14.9	14.6
14.9	15.0	15.4
14.2	14.5	15.2
15.2	15.5	14.5
13.0	13.1	12.7
13.1	13.0	12.8
13.6	13.0	13.3
15.2	15.4	15.0
15.5	16.1	15.4
13.5	13.9	13.6
17.0	15.6	15.7
13.6	13.6	14.4
14.5	14.4	14.4
12.6	11.8	12.2
15.6	16.2	15.3
12.2	12.5	13.2
13.2	13.9	13.5
15.3	16.1	15.0
13.5	12.6	12.9
16.7	16.0	16.4
13.7	13.6	14.6
14.2	14.7	14.8
12.4	12.5	12.4
12.5	12.5	12.5
13.0	13.2	12.5
13.5	13.6	12.9
14.4	13.1	13.0
14.0	13.4	13.5
15.6	15.2	15.9
18.0	18.3	18.3
13.5	13.6	13.3
13.8	13.7	13.8
14.20	14.15	14.16

APPENDIX B

RAW DATA OF SPRINT TIMES

Control Group (B)

Sprinters Below	Day number across 1	2	3	4	5	6	7	8	9	10	11	12
C-1	14.4	14.3	14.6	14.7	14.3	14.5	15.0	14.2	13.6	14.2	13.7	14.3
C-2	13.3	13.5	13.5	13.7	13.4	13.0	13.0	13.0	12.8	13.0	12.9	12.6
C-3	15.2	15.6	15.6	16.6	15.2	14.0	15.0	14.8	13.8	14.0	13.8	13.4
C-4	14.0	13.4	13.9	14.1	13.8	13.9	14.4	13.9	13.5	13.5	13.2	12.8
C-5	14.1	15.4	16.2	15.8	15.6	15.0	15.0	14.3	14.2	14.0	14.0	13.9
C-6	17.5	17.0	17.3	17.3	17.2	16.9	16.5	16.3	16.7	15.9	16.2	15.7
C-7	14.2	13.8	14.0	14.1	13.9	13.4	13.5	13.7	13.5	13.8	13.7	13.7
C-8	15.0	15.0	15.6	15.6	15.2	14.7	15.0	14.0	13.9	14.5	14.4	13.8
C-9	13.3	13.2	13.5	13.7	13.4	13.2	13.1	13.0	12.9	12.7	12.8	13.3
C-10	13.7	13.5	14.3	14.0	14.0	14.4	14.1	13.5	13.1	13.8	13.3	13.5
C-11	13.0	13.6	13.8	13.7	14.7	12.9	13.2	12.8	12.8	13.0	13.0	12.6
C-12	16.6	16.5	17.0	17.3	16.7	16.5	16.8	16.8	16.5	16.4	16.5	15.6
C-13	15.1	14.5	15.2	15.5	15.3	14.9	15.0	14.9	14.6	14.8	14.5	14.3
C-14	14.6	14.4	14.9	14.8	14.9	13.8	13.9	14.0	13.3	13.8	13.5	13.4
C-15	17.7	17.2	17.7	17.9	17.4	17.5	17.6	18.0	16.8	16.1	15.3	14.7
C-16	16.4	17.1	17.8	16.8	17.0	16.5	16.3	16.6	17.2	16.1	16.5	17.0
C-17	14.4	13.9	14.5	14.2	14.4	14.3	13.9	13.9	13.8	13.6	13.7	13.4
C-18	14.9	14.7	15.3	14.9	14.9	14.7	14.6	14.5	14.7	14.5	14.2	14.3
C-19	14.8	14.5	15.0	15.2	15.0	14.5	14.0	14.1	14.1	14.2	14.2	14.0
C-20	15.3	14.3	14.6	15.1	15.0	14.4	14.5	14.0	14.2	14.0	14.3	14.3
C-21	15.0	15.0	15.4	15.9	14.7	15.0	15.1	14.8	13.6	13.8	13.8	13.6
C-22	16.0	15.6	15.0	14.8	14.4	14.9	14.8	14.2	14.4	13.6	14.6	13.9
C-23	16.5	16.6	16.9	16.5	16.1	17.1	16.2	16.1	16.0	16.0	15.9	16.0
C-24	14.0	14.0	14.0	14.3	14.5	14.3	14.4	14.0	13.8	14.1	17.1	13.8
C-25	17.0	17.0	16.7	17.2	16.9	16.6	16.9	15.1	15.4	15.3	15.5	14.9
C-26	14.3	14.3	14.7	15.0	14.9	13.9	14.2	13.8	13.9	14.0	13.6	13.4
C-27	17.2	16.8	16.5	17.2	16.5	16.8	16.7	16.5	16.3	16.4	16.7	15.2
C-28	16.0	16.9	15.1	15.9	16.2	15.2	15.5	16.1	14.7	14.9	14.8	14.7
C-29	13.3	13.4	13.8	14.6	13.4	13.3	13.9	13.3	13.1	13.5	13.4	12.4
C-30	17.4	17.5	18.2	18.9	17.4	17.5	17.9	16.5	16.4	16.6	16.0	17.2
C-31	14.6	14.6	14.9	15.2	14.8	14.4	15.1	14.1	14.1	14.1	13.9	13.4
C-32	13.2	13.1	13.0	13.7	13.0	12.9	13.2	12.9	12.3	12.5	12.8	12.6
C-33	13.7	13.4	13.8	14.0	13.5	13.6	14.0	13.5	13.4	14.2	13.2	13.3
Daily Means	15.01	14.95	15.22	15.40	15.07	14.80	14.91	14.58	14.34	14.37	14.39	14.09

APPENDIX B

Control Group Times Continued From Page 52

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
13.7	14.0	13.9	13.9	13.8	13.4	13.8	13.8	14.0	14.0	13.9	13.4	13.4	13.8	14.1
13.0	12.7	12.6	12.6	12.3	12.4	12.7	12.7	13.0	12.8	13.0	13.1	12.8	13.4	13.2
14.2	13.4	14.2	14.0	13.6	13.3	13.4	13.7	14.0	14.4	14.3	13.9	13.7	13.5	13.7
13.8	13.1	13.2	13.1	13.3	12.9	12.8	13.0	13.2	13.4	13.5	13.6	13.0	12.9	12.9
14.5	13.6	13.9	13.8	14.0	13.5	13.7	13.9	14.2	14.7	15.3	13.4	13.5	13.8	15.0
16.3	16.0	16.3	15.9	15.6	15.9	16.2	16.8	16.9	15.6	15.6	15.1	15.4	15.8	15.6
14.0	13.0	13.6	13.5	13.2	13.2	13.2	13.5	13.4	14.2	14.0	12.6	12.8	13.2	12.9
14.5	14.1	13.8	14.3	14.0	13.6	13.8	14.2	14.3	14.4	15.0	14.4	13.3	13.8	14.3
13.0	13.0	12.7	12.3	12.2	12.6	13.0	13.2	13.2	12.3	12.3	12.5	12.6	12.9	13.0
13.5	13.6	13.5	13.3	13.4	13.9	13.8	14.0	13.1	12.9	13.5	13.5	14.3	14.2	16.9
13.0	13.7	16.0	13.1	13.2	13.3	14.2	13.9	14.0	13.9	13.6	12.9	13.5	12.8	12.8
16.4	16.1	16.0	16.1	16.5	16.9	16.3	15.5	15.6	15.9	15.6	16.0	16.1	15.8	15.5
14.8	14.2	14.3	14.2	14.0	13.9	13.5	14.0	14.5	15.1	14.9	14.6	14.2	14.4	14.2
13.2	13.2	13.6	13.8	13.5	13.0	12.8	13.2	13.7	14.4	13.7	13.5	14.0	14.5	13.5
17.3	15.4	17.0	16.1	16.9	16.5	16.2	15.8	15.9	17.6	17.2	16.1	15.4	15.4	15.5
16.6	16.1	15.8	15.5	15.8	16.2	15.5	16.4	16.7	15.6	15.0	15.9	15.9	15.6	15.9
14.0	13.7	13.8	13.8	14.0	15.0	15.2	15.2	14.0	13.6	13.9	13.3	13.4	13.4	13.2
13.8	14.0	14.3	15.2	14.8	15.2	14.2	13.9	14.7	15.1	15.0	15.0	16.3	16.2	14.5
14.5	14.0	14.3	14.5	14.0	13.6	13.6	13.5	14.2	13.9	14.1	14.0	13.3	13.4	13.7
14.3	14.3	13.7	13.6	14.6	14.2	14.7	15.4	14.9	13.6	13.6	14.0	14.0	13.8	14.1
14.3	13.8	14.1	14.1	13.7	13.6	13.4	13.5	14.3	14.3	15.0	14.4	13.5	13.9	14.0
14.6	14.1	14.0	13.8	13.4	13.7	14.2	14.1	14.8	14.3	13.6	13.7	14.2	13.8	14.2
14.6	15.4	15.4	15.7	15.5	15.0	15.2	15.7	16.9	16.2	15.6	15.6	15.4	15.4	15.9
14.1	13.6	12.7	13.6	13.6	13.8	13.8	13.8	13.9	14.5	14.0	14.0	13.6	13.7	13.6
16.3	15.4	15.0	15.5	15.8	15.5	15.4	15.5	16.0	16.5	16.3	15.4	15.0	15.5	15.3
14.2	13.8	13.7	13.8	14.4	14.0	14.4	13.3	13.8	14.5	14.2	13.6	13.4	13.8	13.6
16.2	16.2	16.0	16.1	16.8	15.9	16.2	16.4	16.2	16.0	15.0	15.5	15.5	15.7	16.5
14.9	14.9	15.5	14.7	15.9	14.6	14.5	14.9	14.2	15.1	14.9	14.1	14.2	15.2	15.1
13.1	13.0	12.6	12.8	13.0	12.8	12.9	13.1	13.0	13.5	14.0	13.2	12.9	12.6	12.9
16.6	15.9	16.3	16.3	17.0	17.3	15.9	16.2	16.5	16.9	16.9	15.8	17.5	19.0	18.2
14.5	13.8	13.5	13.9	14.0	14.0	13.5	14.2	13.9	15.1	14.5	13.4	13.3	13.6	14.0
12.8	12.5	12.9	12.8	13.0	12.5	12.3	12.5	12.5	13.5	13.2	12.3	12.1	12.6	12.9
13.0	13.3	13.5	13.8	13.9	13.2	13.4	13.5	13.3	13.5	13.6	13.4	14.2	14.0	13.7
14.47	14.40	14.29	14.22	14.32	14.19	14.17	14.25	14.46	14.58	14.48	14.09	14.11	14.28	14.34

APPENDIX B

Control Group Times Continued From Page 53

28	29	30
13.7	14.3	14.5
12.5	13.2	13.2
14.5	14.9	14.9
13.1	12.7	12.8
13.8	14.4	15.0
16.2	16.5	17.1
13.2	12.9	13.5
14.5	15.4	15.1
13.1	13.5	12.7
16.5	14.5	14.9
13.0	12.7	12.9
15.4	15.6	15.5
14.7	14.0	14.0
14.0	14.2	13.6
16.3	15.9	16.8
15.4	16.0	16.0
13.3	13.5	13.2
15.0	16.1	16.0
13.9	14.0	14.2
15.0	14.8	14.4
14.2	14.7	14.8
14.5	15.2	15.1
15.9	15.8	16.2
14.0	14.2	14.0
15.4	16.8	16.5
14.0	14.2	15.2
16.1	16.5	17.0
14.6	15.0	18.0
13.3	13.2	13.8
17.0	17.0	16.9
14.4	14.6	14.7
12.7	12.8	13.8
13.5	14.4	13.4
14.44	14.65	14.83