6-1-1966

The Effect of Handweights in Starting Practice on Speed of Sprinters

James E. McCullough

This abstract of a thesis submitted by James E. McCullough in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

W. C. Koenig
Chairman

Dean of the Graduate School

THE EFFECT OF HANDWEIGHTS IN STARTING PRACTICE ON SPEED OF SPRINTERS

James E. McCullough, Master of Science

The thesis here abstracted was written under the direction of Walter C. Koenig and John L. Quaday and approved by Joseph S. Zaccaria as a member of the examining committee, of which Mr. Koenig was chairman.

This study was undertaken to determine the changes elicited by the use of hand weights during sprint training.

Forty-three University of North Dakota freshman male students from two physical education service classes served as subjects. The control group consisted of fourteen subjects which participated in the pre- and re-test and the rest of their time was spent in required activities which were unrelated to the study. Experimental Groups I and II contained fifteen and fourteen subjects respectively, which participated in similar sprint training programs. The only variation of the training of Experimental Groups I and II was the attachment of three pound hand weights to each hand and wrist of the subjects in Experimental Group II.

Each group was tested prior to, and at the end of, a six week training program. The test was a 50-yard dash, run from starting blocks, employing a bunch start.

The significance of difference between the pre- and re-test means within each group was tested by the "t" technique for correlated scores from small samples. Rejection of the null hypothesis was assumed at the .01 level of confidence.

Comparisons were made between groups to establish whether there was any significant difference. For this purpose the standard

error of the difference between means of uncorrelated samples was tested for significance at the .01 level of confidence.

The conclusions drawn from this study were:

1. The Control Group and Experimental Groups I and II made significant improvement at the .01 level of confidence in running speed during the experimental period as measured by the 50-yard dash.

2. Although all three groups improved their running times in the 50-yard dash significantly at the .01 level of confidence, there was no significant difference between the improvements each of the groups made.

3. The analyses of data indicated critical ratios or t values for the Control Group of 3.27, Experimental Group I of 4.00, and Experimental Group II of 7.05. From these critical ratios it can be assumed that Experimental Group II improved more than Experimental Group I, and that Experimental Group I improved more than the Control Group, even though the improvements for each of these groups is significant at the .01 level of confidence.

THE EFFECT OF HANDWEIGHTS IN STARTING

PRACTICE ON SPEED OF SPRINTERS

by

James E. McCullough

B.S. in Education, University of North Dakota 1965

A Thesis

Submitted to the Faculty

of the

Graduate School

of the

University of North Dakota

in partial fulfillment of the requirements

for the Degree of

Master of Science

Grand Forks, North Dakota

June

1966

This thesis submitted by James E. McCullough in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

W. C. Koenig
Chairman

John L. Quaday

J S Zaccaria

Christopher J. Hamre
Dean of the Graduate School

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation for the valuable assistance rendered by Mr. Walter C. Koenig and Dr. John L. Quaday. Their helpful suggestions and constant guidance were of utmost importance while completing this study.

A deep appreciation is expressed to the author's wife, NoDean, whose encouragement, patience, moral support, and suggestions were of immeasurable importance in the completion of this study.

TABLE OF CONTENTS

Chapter	Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

The words which border the top of the Olympic Shield, "Fortius-Altius-Citius" (stronger-higher-swifter), are the most accurate description for the sport of track and field. Athletes of today are throwing farther, jumping higher, and running faster than ever before and the accomplishments are being achieved by much younger athletes.

Examples of the improvements which have been made by high school athletes can be seen by reviewing their achievements from the year 1946 through 1963, in just one event, the 100-yard dash.

The Athletic Journal lists the ten best performances each year by high school athletes whose schools are members of their State High School Athletic Associations. The performance must be made in interscholastic competition at a meet which involves five or more schools. In running events recognition is given only to winning performances without wind assistance.

From these reports one can see that the fastest 100-yard dash run in 1946 was timed at 9.7 seconds, with four boys running in 9.8 seconds and five being timed at 9.9 seconds.[1] The great improvement in the time for 1963 shows the fastest time as 9.4

---

[1]Anonymous, "Track in the High School," Athletic Journal, XXVII (February, 1947), p. 26.

seconds, with four boys running 9.5 seconds and seven boys running at 9.6 seconds.[2]

From these running times it may be seen that high school athletes have to run much faster to win races and also much faster to collect valuable team points by placing in the second, third and fourth positions.

There are many factors responsible for the improved performances not only in track and field, but in all the other forms of competition. Some of the factors given credit for these improved performances are new training methods, better qualified coaches, better competition, comfort of travel, better diets for athletes, better officials, and improved facilities and equipment with which to work. Many of the training methods which have recently evolved to keep pace with the great athletic achievements are still in the controversial stage. A great deal of investigation is needed in the different areas of track and field to determine the validity of the training methods which are employed.

Within recent years, training with weights was thought to be detrimental to athletes. Through a number of studies, this type of training has gained a wide acceptance and is now employed by athletes in almost all sports during their training program.

With the acceptance of training with weights, the writer is interested in the training method which attaches the weight to the body. More specifically, the writer is interested in whether methods

---

[2]William W. Russell, "National Honor Roll," <u>Athletic Journal</u>, XLIV (January, 1964), p. 37.

which employ hand weights will improve the performance of sprinters out of the starting blocks.

One of the benefits of using hand weights might be to improve arm action which would enable an athlete to improve his starting time. The main fault of most sprinters is to fail to use their hands and arms in the most advantageous manner.

Ecker explains this fault as follows:

> "Many sprinters tend to 'run through the loop' formed by their arms as they come out of the blocks. In contrast with the vigorous, driving arm action which should be used, their arms form a loop which they practically step through before arm action is begun."[3]

The fault of "running through the loop" is not in accordance with the theory by Dunn,[4] that a sprinter should use every available means of gaining speed, which means that the arm swing should be as forceful as possible.

Statement of the Problem

The problem of this study was to determine the effect of training sprinters with the use of hand weights in practicing starts, as to their speed performance in running the 50-yard dash.

Need for the Study

The writer feels that, because there are many techniques in coaching track and field which coaches do not agree upon, there is need for further investigation in all of the track and field events.

---

[3]Tom Ecker, Championship Track and Field (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961), p. 6.

[4]John W. Dunn, Scientific Principles of Coaching (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962), p. 108.

Some coaches have met with success; and in many cases it is not known if this success was achieved because of the method used or in spite of the method which was used.

This study represents an effort on the part of the writer to contribute some additional data and findings to track and field athletics, especially in the area of using hand weights in the training of sprinters.

Purpose of the Study

The purpose of this study was to determine whether training with hand weights would have any effect on the speed performance of sprinters in running the 50-yard dash.

Delimitations of the Study

This study was limited to:

1. The freshman male students selected from two physical education service classes at the University of North Dakota.

2. The training of fifteen subjects in Experimental Group I and Experimental Group II.

3. The selection of subjects was based on the times run in one 50-yard dash.

4. A training period of six weeks in which the subjects met two hours per week.

5. The data secured from the pre-test and re-test.

Definition of Terms

American Association for Health, Physical Education and Recreation Youth Fitness Test - is a motor fitness test which includes:

pull-ups, sit-ups, 40-yard shuttle run, standing broad jump, 50-yard dash, softball throw for distance, 600-yard run-walk, and three aquatic tests.[5]

Bunch start - is a starting position in which the toe of the back foot is placed opposite the heel of the front foot while in a standing position. This start represents the one extreme in foot spacing since sprinters seldom place the feet closer together than described in bunch starting.[6]

Control Group - consisted of fourteen freshmen male students who participated in a regular physical education service class involving unrelated activities.

Experimental Group I - consisted of fifteen freshmen male students who participated in a six weeks sprint training program employing starting blocks and a bunch start.

Experimental Group II - consisted of fourteen freshmen male students who participated in a six weeks sprint training program employing starting blocks, a bunch start, and a three pound hand weight attached to each hand.

Hand weights - consisted of small heavy canvas pouches, containing three pounds of buckshot that were attached to the wrist and hand by means of two leather straps.

---

[5]H. Harrison Clark, Application of Measurement to Health and Physical Education (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1960), p. 237.

[6]George T. Bresnahan, W. W. Tuttle, and Francis X. Cretzmeyer, Track and Field Athletics (St. Louis: The C. V. Mosby Co., 1960), p. 81.

Mean - is best defined as the sum of all the scores divided by the total number of scores.[7]

Overload - means performing against increased resistance. This can be produced by working against an increased load, by progressive speed or by carrying a slow paced or unpaced activity to limits beyond those which are easily met by the individual.[8]

Subjects - refers to all the freshman male students who participated in the Control Group, Experimental Group I, and Experimental Group II.

---

[7]C. C. Ross and Julian C. Stanley, Measurement in Today's Schools (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963), p. 73.

[8]C. Etta Walters, "Scientific Foundations of the Overload Principle," Scholastic Coach, XXVII (March, 1958), p. 20.

CHAPTER II

REVIEW OF LITERATURE

Speed of foot has been of great interest as long as man has existed. Speed is the greatest asset one can have in almost all sports. It is the basic ingredient of such sports as basketball, baseball, football, soccer, and track and field.

The supreme test of speed is in the sprints. Mortensen and Cooper[1] define a sprint as an all out effort by the contestant to move as fast as he can, over the indicated distance in as short a time as possible.

Characteristics an athlete must possess to be a sprinter are: speed, strength, relaxation, nervous temperament, and age. The most important is natural speed, but the factor which can be changed the most through a training program is strength. The importance of a sprinter being strong is explained by Ecker,[2]

> A boy must be physically strong in order to be a good sprinter. Sprinting is a strength exercise. More muscle strength is required for sprinting than for any of the longer races.

Strength has also been recognized as an important attribute to be possessed by athletes in many other sports. Because of this

---

[1]Jesse P. Mortensen and John M. Cooper, Track and Field for Coach and Athlete (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1959), p. 13.

[2]Ecker, loc. cit., p. 3.

interest in improving an athlete's strength with the purpose of improving his ability in performance, the topic of weight training has become a very controversial subject. Many physical educators believe that weight training is a hindrance to any type of athletic training because it makes participants "muscle bound." "Muscle bound" is a vague term which has been given a number of different definitions. Some of the characteristics which individuals are supposed to possess when they are "muscle bound" are: (1) muscles which are in a permanent state of partial contraction, (2) limited agility, (3) reduced speed, (4) hinderance when trying to learn sport skills, and (5) undue strain on the body.

Conversely, there are many people who believe weight training is a worth-while sport which can improve one's proficiency in most sports, and also develop physical fitness. Whether one agrees or disagrees with the value of weight training, it cannot be denied that this method of training is becoming more popular and widespread.

Coaches of track and field were probably the last to employ weight training, particularly for athletes in the running and jumping events. These coaches believed that progressive resistance exercises can increase the strength and endurance of the muscles, but such training decreases the muscles' speed of contraction. Since muscle properties such as elasticity, flexibility, and speed of contraction were considered to be of greater importance than strength, weight training was looked upon with skepticism by some coaches of track and field.

To illustrate how the belief that weight training is detrimental to track and field athletes has changed, Nelson[3] states:

> "Weights, once hardly used by track and field athletes, now have become so accepted that they are moving on to the body where they are worn during practice of the actual event. There are weighted jackets, weights for the wrists and ankles, and weights to be carried in the hands while running."

Weight training improves muscular co-ordination rather than makes one "muscle-bound." This has been proven by the fact that many of the world's outstanding athletes in recent years have been men who have trained their bodies with weights. In spite of all sorts of wild claims of how weight lifting would slow one down, these athletes, in many instances, surpassed the best performances on record. Notable among them have been such famous athletes as Bob Mathias, Fortune Gordion, Bob Richards, Mal Whitfield, Bob Connolly, Billy Cannon, Frank Stranahan, and countless others. Certainly, if weight training would cause one to become slow, stiff, and muscle bound, the great athletes just mentioned would never have been able to achieve the amazing success which has given them world renown.[4]

With this illustration that many of the most successful track and field athletes in the world train with weights, Ecker[5] also comments on how this training method can be of great importance to coaches and athletes who want to increase sprinting speed.

---

[3]Bert Nelson, "Of People and Things," Track and Field News, XIII (February, 1960), p. 10.

[4]Tony Terlazzo, "What is Weight Training?" Physical Power (March-April, 1960), p. 8.

[5]Ecker, loc. cit., p. 19.

> Coaches and athletes are just beginning to scratch the surface of weight training. Although many new ideas are sure to develop, it is generally known that the day when a weakling can become a good sprinter is behind us. The boys who will win races in the future are the boys who are physically strong. Because of this, most coaches are beginning to have their athletes use resistance exercises in the form of barbells, dumbbells, weighted jackets, and leg weights.

The writer of this study was concerned with weight training in which weights were actually attached to the athlete's body. Because of this concern, the remaining review of literature was limited to previous studies concerned with the use of weights in training. The review was divided into two groups: weight training which involves the use of weights which were actually attached to the body, and weight training which employed the usual apparatus in the form of barbells and dumbbells. Some of these studies are significant here since they encompass strength and speed which have been determined to be of great importance to a sprinter.

<u>Weights Which are Attached to the Body</u>

The studies which were available to the writer on the methods of training in which weights were attached to the body were limited. There were no thorough studies available which involved this type of training in track and field athletics. However, there were a number of articles written which seemed to indicate that this type of training is becoming more popular with coaches throughout the country.

Jesse[6] stated his beliefs on training with weights attached to the body, in a speech given at the National Collegiate Track Coaches Association Track Clinic in Eugene, Oregon. His beliefs were:

---

[6]John P. Jesse, "A New Look at Strength Development in Track and Field Athletes," <u>The Physical Educator</u>, XXII (May, 1965), p. 72.

> The problem involved in the use of weights attached to the body during practice of the event itself, involves the principle of "specificity of training." Each event makes specific demands in terms of its pattern of load, rate, repetition, and duration. The neurophysiological adjustments to these demands are so specific and so precise that a slight change in the weight of a javelin, shot, or discus or weight added to the body in a jump will effect the trained athlete's performance in terms of speed, timing, and coordination. There is no harm in attaching weights to the body if this type training is not used in the practice of any event that requires skill. It could be of benefit to long distance, marathon, or cross-country runners where the objective is an increase in muscular endurance. There is no harm in attaching weights to the body for the development of power if the movement used is not the event itself.

From Jesse's statement that weights should not be attached to the body when practicing the actual event, one might conclude that such a training method should not be employed by sprinters when practicing starts. With further investigation, the writer found that such a training method produced very satisfactory results.

Hanke[7] conducted a study in 1960, in which two sprinters wore weighted vests totaling ten pounds. He compared these two sprinters with two subjects who did not train with the weighted vests. The training period lasted three weeks in which the subjects met three afternoons per week. At each training session, each subject practiced five starts at distances of ten and twenty yards.

Detailed records of their five fastest times of the previous year were compared with the five fastest times of the current season. It was found that the two boys who trained with the weighted vests made the greater improvement. One weight trained subject improved his best time of the previous year from 10.06 seconds to 9.88 seconds, a

---

[7]Al Hanke, "Weight Vests for Improving Track Athletes," Athletic Journal, XLII (December, 1961), p. 30.

1.78 per cent improvement and the other weight trained subject improved from 10.56 seconds to 10.31 seconds, a 2.37 per cent improvement. The two subjects who did not use the weighted vests in practicing their starts also improved, but not as much. One subject's time improved from 10.52 seconds to 10.42 seconds, a 0.95 per cent improvement and the other subject's time improved from 10.62 seconds to 10.48 seconds, an improvement of 1.32 per cent.

Burnham[8] conducted a study on the effects of circuit training in which the subjects wore weighted vests. The duration of the training period was eight weeks and the subjects were fifteen college men. The results indicated that all subjects showed improvement on the items tested: push-ups, jump for height, sit-ups, and shot put. The writer questions the results of this study because there was not any type of control group with which comparisons could have been made.

In 1961, Kenneth A. Anderson[9] undertook a study in an attempt to determine the effects of training with the weighted ankle spat on the jumping performance, agility and endurance of high school basketball players.

Anderson used two experimental groups for his study. One group took part in all training activities with a three pound spat on each basketball shoe. The second group took part in all the training activities without an overload of any type.

---

[8]Stan Burnham, "Circuit Training," (Unpublished research paper, Department of Physical Education, University of Texas, no date).

[9]Kenneth A. Anderson, "The Effect of the Weighted Ankle Spat on the Jumping Performance, Agility, and Endurance of High School Basketball Players," (Unpublished Master's Thesis, University of Wisconsin, 1961).

The training period covered seven weeks and consisted of: (1) rope jumping, (2) lap running, (3) volleyball games, (4) relays and sprints, and (5) bleacher running.

The group which wore the weighted spats showed the greatest improvement on the three test items: vertical jump, Illinois Agility Run, and a three-hundred-sixty yard shuttle run. This improvement was significant at the .05 level of confidence.

Lukas[10] conducted a study similar to the one previously mentioned. The main difference was his subjects, who were college basketball players instead of high school basketball players.

The length of the study was five weeks. Lukas employed two experimental groups and a control group, which did not take part in the training program. One experimental group trained with the regular basketball shoe while the second experimental group trained with a weighted basketball shoe. From the data, Lukas drew the following conclusions:

1. Although both the weighted shoe and regular shoe groups made greater gains than the control group, there was no significant difference between the three groups in the standing broad jump.

2. The gains in endurance made by the weighted shoe group were significantly greater than the gains made by the regular shoe group over the control group.

3. Although there was no significant difference, the weighted shoe group showed a mean increase in the thirty-yard dash from the

---

[10] D. Wayne Lukas, "The Effect of a Weighted Training Shoe on the Jumping Performance, Agility, Running Speed, and Endurance of College Basketball Players," (Unpublished Master's Thesis, University of Wisconsin, 1960).

pre-test to the final test which was greater than the gain made by the regular shoe group.

4. There was no significant change (pre-test to final test) between regular shoe and weighted shoe groups in agility.

Simpson[11] conducted a study to determine the effects of weighted equipment on speed, endurance, agility, and power of junior varsity football players at Aitkin, Minnesota. His control group consisted of sixteen subjects which participated in a regular football conditioning program. His experimental group consisted of sixteen subjects who participated in the same conditioning program but each subject wore ankle weights of two and one-half pounds each and a weighted vest of nine pounds. The findings of this study with regard to speed showed that both the control group and the experimental group improved significantly at the .01 level, however, there was not any significant difference in the improvement between these two groups.

Tait[12] conducted a study on the effects of ten-pound training jackets on endurance in sophomores at Pennsylvania State University. Subjects in the control group trained in the same training program but did not wear the weighted jackets. The training period covered five weeks, three hours per week, in which all subjects ran repetitive distances ranging from two-hundred-twenty yards to one mile. From the

---

[11]Wayne F. Simpson, "The Effect of In-Season Use of Weighted Equipment on Speed, Endurance, Agility, and Power of High School Football Players," (Unpublished Master's Thesis, University of North Dakota, July, 1963).

[12]George Thomas Tait, "The Effect of Wearing Ten-Pound Training Jackets on the Development of Endurance for Running," (Unpublished Master's Thesis, Pennsylvania State University, 1961).

pre-post test results for endurance, Tait concluded that the weighted jackets did not materially affect the development of endurance within the five weeks period.

These are the only studies available to the author at this time which involve training methods which attach the weights to the athlete's body. From these studies one may conclude that this relatively new training method has had some effect on the improvement of performance, but also that much more research is needed in this area to determine the effect of such training procedures.

Conventional Weight Training Programs

Experiments with various weight training programs and their effects upon performance in various skills and activities have been steadily increasing.

Meisel[13] conducted a study to determine the effect of a weight training program on running speed. The subjects which participated in this study were freshman and sophomore male students at Pennsylvania State University. The experimental group consisted of fifty-two volunteer subjects who were enrolled in a weight training class. This group participated in a special weight training program for a period of seven weeks. The control group also consisted of fifty-two volunteer subjects, but they did not participate in any type of running or weight training program. From the data collected on the test and re-test, Meisel drew the following conclusions:

---

[13] Stephen Gaylor Meisel, "The Effect of a Weight Training Program on the Speed of Running," (Unpublished Master's Thesis, Pennsylvania State University, 1957).

1. Progressive weight resistance exercises significantly increased the strength of the legs as measured by a back and leg dynamometer.

2. The program of progressive weight resistance exercises caused a loss of speed in running a distance of ten yards at maximum speed. This decrease in speed was statistically significant at the .02 level of confidence.

Woodall,[14] in an attempt to determine the effects of increased arm and upper body strength upon running speed, equated twenty-four subjects in the experimental and control groups on the basis of their scores in the 100-yard dash. After a six week period of weight training for the experimental group, all twenty-four subjects were retested in the 100-yard dash. No significant difference was noticed between the running times of the experimental group and the control group, who did not benefit from a weight-training program during the six week period.

Vanyo[15] conducted a study using subjects from Richardson Junior High School in San Bernardino, California. His study was concerned with the effects of weight training concentrated on the arms and shoulders and its effects upon running speed in the sixty-yard dash. After the sixty day training period he drew the following conclusions:

---

[14]Thomas Woodall, "Weight Training of the Arms and Upper Body and Its Effect Upon Speed in High School Boys in the 100-yard Dash," (Unpublished Master's Thesis, Colorado State College, 1960).

[15]Raymond J. Vanyo, "Weight Training Concentrated on the Arms and Shoulders and Its Effect Upon Speed of Junior High School Boys in the Sixty Yard Dash," (Unpublished Master's Thesis, University of North Dakota, 1963).

1. After a sixty day weight training program for the arms and upper body, the group mean speed in the sixty yard dash was improved. The improvement was significant at the one per cent level of confidence.

2. A sixty day period of weight training did significantly change the running time for the measure of the sixty yard dash.

3. That the sixty day period of the weight training group showed a greater improvement in running speed than the non-weight training group although both groups were significant at the .01 level; however, the difference between the improvement made by the weight training group and that which was made by the non-weight training group was not significant at the .01 level.

To determine the effects of the use of near-maximum weights on the running and jumping ability of first-year high school track men, Helixon[16] randomly assigned twenty-four subjects to a control and experimental group. The experimental group received a weight-training program five days weekly for a period of six weeks, while the control group remained idle. No significant difference was found between the control and experimental groups on the measures; vertical jump, 100-yard dash, running broad jump, and the one-mile run.

Chui[17] conducted a similar study to determine the effects of systematic weight training on power as related to jumping, the shot put, and the sixty yard dash. Increases in running speed were only

---

[16]Patrick Helixon, "The Effects of Progressive Heavy Resistance Exercises Using Near-Maximum Weights on the Running and Jumping Ability of First-Year High School Track Performers," (Unpublished Master's Thesis, University of Wisconsin, 1961).

[17]Edward F. Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, XXI (October, 1950), pp. 188-194.

slight. It was concluded that running speed possibly could be improved through systematic weight training.

In 1964, Chui[18] conducted another study to investigate the comparative effects of isometric and dynamic weight training exercises on two physical qualities, strength and speed of selected movements.

Ninety-six men at the State University of Iowa were used as subjects for the duration of the study which took nine weeks. The findings were:

1. Gains in strength made by the use of the isometric contraction method are not greater than gains made by the use of dynamic contraction methods of weight training exercises. Also, gains made by the use of rapid contraction method are not significantly greater than gains made by the slow contraction method.

2. Gains in strength exerted in performing a movement are accompanied by gains in the speed of execution of the same movement measured against no resistance.

3. Gains in the speed of movement measured against no resistance made by the use of the isometric contraction method are not significantly greater than gains made by the use of dynamic contraction methods.

In a study conducted by Capen,[19] attempts were made to determine the effects of systematic weight training on strength, athletic power

---

[18] Edward F. Chui, "Effects of Isometric and Dynamic Weight-Training Exercises Upon Strength and Speed of Movement," Research Quarterly, XXXV (October, 1964), pp. 246-257.

[19] Edward Capen, "The Effects of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, XXI (May, 1950), pp. 83-93.

and muscular and circulo-respiratory endurance.

Capen used two groups in his study. One group was a weight training class and the second group was a conditioning class.

All subjects were tested with the Sargent jump standing, Sargent jump running, standing broad jump, eight-pound shot put from a stand, and a sixty-yard sprint.

Upon completion of the training period, all subjects were retested in the above areas. An analysis of the data failed to reveal a significant difference between the two groups in muscular endurance and circulo-respiratory endurance. The weight-training group did improve significantly more than the conditioning group in the speed measures. It was concluded that weight-training as used in this experiment, does not produce muscular tightness or decrease of speed in muscular contraction as is commonly assumed by many track and field coaches.

In a study at the Inter-American University of Puerto Rico, Dintiman[20] used 145 students to determine whether a flexibility training program and a weight training program would affect running speed when used as supplements to the conventional methods of training sprinters. Dintiman used three experimental groups: (1) sprint training and flexibility program, (2) sprint training and weight training program, (3) sprint training, flexibility and weight training program, and two control groups: (1) sprint training, and (2) an inactive group.

---

[20]George Blough Dintiman, "Effects of Various Training Programs on Running Speed," <u>Research Quarterly</u>, XXXV (December, 1964), pp. 456-463.

The conclusions from his study were:

1. The flexibility training program, used as a supplement to sprint training, did not improve running speed significantly more than the sprint training program alone.

2. The weight training program, used as a supplement to sprint training, did not improve running speed significantly more than the sprint training program alone. However, a difference in adjusted means of only 0.01 prevented significance at the .05 level.

3. The combination of the flexibility and weight training programs, used as supplements to the sprint training, improved running speed significantly more than the sprint training program alone.

Fishbain[21] conducted a study to determine the effect of weight training upon performance in the 35-yard dash, standing broad jump, and 20-foot rope climb. His control and experimental groups each consisted of twelve subjects. The experimental group engaged in a nine-week weight training program, while the control group was involved only in the regular physical education program.

Subjects were pre and post tested in the above mentioned areas and an analysis of covariance was computed to determine whether significantly different changes occurred. The experimental group increased significantly more in the dash and broad jump. However, no significant differences were found in the rope climb.

---

[21] Jerome Fishbain, "The Effects of a Nine-Week Training Program Upon Measures of Dynamic Strength of Adolescent Males," (Unpublished Master's Thesis, University of Wisconsin, 1960).

In a study by Masley[22] to determine whether increased strength gained through weight training was accompanied by an increase in muscular co-ordination and speed of movement, the following conclusions were drawn:

1. The weight training group showed a greater increase in speed and co-ordination.

2. The increased strength gained through weight training had a close relationship with increase in speed and co-ordination.

3. The weight training group showed a significant increase in strength over the non-weight training group.

Several studies have been conducted to determine the effects of weight training upon the speed of muscular contraction, since many coaches and physical educators believe that weight training has a detrimental effect upon speed of movement.

Zorbas and Karpovich[23] conducted an investigation to determine the effects of weight training on the speed of movement of a single arm turning a crank in a frontal plane. Three hundred weight lifters and body builders at the 1950 Senior National AAU Weight Lifting Championship and Mr. America contest were compared with one hundred and fifty men from Springfield College and one hundred and fifty men from a Liberal Arts College.

---

[22]John W. Masley, "Weight Training in Relation to Strength, Speed, and Coordination," Research Quarterly, XXIV (October, 1953), pp. 308-315.

[23]William S. Zorbas and Peter V. Karpovich, "The Effects of Weight Lifting Upon the Speed of Muscular Contractions," Research Quarterly, XXII (May, 1951), pp. 145-148.

The findings of this study revealed that the weight lifting groups were significantly faster than the control group and that the Springfield College students were significantly faster than the Liberal Arts College students.

Wilkin[24] conducted a study at the University of California to test the speed of movement of the arm action of a group of students before and after a semester of elementary weight training, and to test the speed of arm movement of a group of experienced university weight lifters as compared to a control group. The elementary weight training group averaged one hour and fifteen minutes of lifting per week as compared to one hour per day averaged by the experienced university weight lifters. The control group participated in an elementary swimming and golf class. The findings of this study disproved the belief that weight lifters become "muscle bound." The findings were:

1. Weight training, over a period of one semester, has no slowing effect on speed of arm movement as measured in this study.

2. The chronic weight lifter is not "muscle bound" in the sense that his speed of movement is impaired. His speed is as great as that of other students studied, and improves as much or more during a semester of training.

3. A semester program of weight training does not increase speed of movement more than a semester of beginning swimming or golf.

4. Individual differences in maximum speed of arm movement are definitely present, but there is no significant difference between the

---

[24]Bruce M. Wilkin, "The Effect of Weight Training on Speed of Movement," Research Quarterly, XXIII (October, 1952), pp. 361-369.

weight lifters and the students who participated in swimming and golf.

Summary of Related Literature

From the review of related literature it may be seen that some researchers have reported significant speed increases following weight training programs and others have failed to do so. Since weight training programs produced a significant gain in strength, and it is imperative for an athlete to be strong to be a good sprinter, one may make a general hypothesis that a weight training program which involves the use of hand weights will increase a sprinter's starting ability and thereby improve his sprinting time. This hypothesis is based on the following conclusions supported by the related literature.

1. Weight training has no detrimental effect upon the speed of muscular contraction of the arm.

2. Weight training programs produce significant increases in strength.

3. An athlete must definitely be strong to be a good sprinter.

CHAPTER III

METHODS AND PROCEDURES

The physical education service program for first semester freshman male students at the University of North Dakota is divided into six weeks of conditioning, one week to administer the American Association of Health, Physical Education, and Recreation Youth Fitness Test, and eight weeks of skilled activities.

The experimental period for this study began after the completion of the conditioning and testing programs. The physical education service program class met twice a week for one hour periods.

Selection of Subjects

The subjects used in this study were freshman male students participating in the physical education service program at the University of North Dakota.

Forty-five subjects were selected from two physical education service classes. The selection of these forty-five subjects was based on their pre-test, 50-yard dash times. The pre-test was administered during the first regular class meeting which followed the conditioning program.

These forty-five subjects were placed into three equal groups of fifteen subjects each. The placement of subjects into the three groups was based upon the 50-yard dash times of the pre-test.

The fifteen subjects selected to participate in the Control Group were enrolled in a different activity class than the subjects in Experimental Group I and Experimental Group II. The selection of the fifteen Control Group subjects was made after pre-testing nineteen freshman male students. The pre-test Control Group 50-yard dash times, arranged from fastest to slowest, were used for matching purposes.

Forty-nine freshman male students were then pre-tested in a 50-yard dash. Thirty were selected to participate in Experimental Groups I and II. The placement of these thirty subjects into their respective groups was determined by matching their times with those of the established Control Group.

Of the forty-five subjects who were selected to participate in the study, two were dropped before its completion. One subject was a member of the Control Group who was not present for the re-test and the other subject was a member of Experimental Group II who did not complete the training period. This resulted in a total of forty-three subjects with the Control Group and Experimental Group II each containing fourteen subjects and Experimental Group I consisting of fifteen subjects.

After the two subjects were dropped from the study and the three groups were permanently established, a between-group t test was computed using the pre-test 50-yard dash times of the three groups. The result was used to determine whether or not the groups were similar and could be considered equated.

Testing Procedure

In this study the testing procedure consisted of a pre-test and re-test of the fifty yard dash, run from starting blocks, employing a bunch start.

All subjects were compelled to use the bunch start so that no subject would have been at a disadvantage. This method was based on the findings of Dickinson[1] in a study which concluded that the foot placement in the bunch start resulted in the fastest starting time.

The starting commands of, "On your marks," "Get set," and "Go" were given verbally. This procedure was used because the subjects had never experienced starting a race when a starting pistol was employed. This procedure was used in the pre-test and re-test. These verbal commands were used for Experimental Group I and Experimental Group II during the training period.

The timing instruments employed in this study were three stop-watches calibrated in tenths of a second. These three watches timed each subject and the mean time of the three watches was used for the time of that particular 50-yard dash. The timing was done by three graduate students in physical education at the University of North Dakota. These three timers were familiar with the starting procedure used in this study and had previous experience in working a stop watch.

---

[1]A. D. Dickinson, "A Study of the Relationship Between Foot Spacing, Starting Time, Speed in Sprinting, and Physical Measures," (Unpublished Master's Thesis, State University of Iowa, 1933).

Training Period

The training period covered six weeks. During this time the Control Group participated in the pre-test and re-test and the rest of the time was spent in the unrelated activities of volleyball, wrestling, and gymnastics.

Experimental Group I and Experimental Group II participated in identical sprint training programs. The only difference in the training of these two groups was that Experimental Group II wore three pound hand weights on each hand during every training session.

The training program consisted of taking ten starts from the starting blocks twice a week during the six week period. Each of these starts was run at maximum speed for from twenty to thirty yards.

During the practice of the sprint starts the investigator was interested in correcting the following techniques which may have been performed incorrectly: (1) entering the starting blocks, (2) hand placement, (3) hip elevation, (4) hand and arm action, and (5) body mechanics out of the starting blocks.

Statistical Procedure

Following the collection of data, it became necessary to choose a method of analysis that would test the significance of the difference between the means on the pre-test and re-test for the Control Group, Experimental Group I, and Experimental Group II. The null hypothesis was assumed in analyzing the differences between these means. This hypothesis asserts that there is no true difference between two population means, and that the difference found between sample means is, therefore, accidental and unimportant.[2]

There are several methods used to test the null hypothesis. To make within group comparisons of the means for the Control Group, Experimental Group I, and Experimental Group II, the t technique for testing the significance of the difference between means derived from correlated scores from small samples was suitable for use in this study.[3]

To make between group comparisons of the means for the Control Group, Experimental Group I, and Experimental Group II, the t technique for testing the significance of the difference between the means appeared most suitable in this study. This test determines the ratio between the mean difference and the sampling error of the difference. This ratio was expressed as t and was verified in a table of t.[4]

For this study it was decided to retain the null hypothesis at the .01 level of confidence. This means that if this study were repeated one-hundred times, ninty-nine per cent of the studies would have similar results.

The standard deviation was calculated from the original data by using The Short Method according to Garrett.[5]

The standard error of the mean was calculated using Garrett's formula for small samples.[6]

---

[2]Henry E. Garrett, Statistics in Psychology and Education (New York: Longmans, Green and Co., 1958), p. 213.

[3]Quinn McNemar, Psychological Statistics (New York: John Wiley and Sons, Inc., 1949), p. 225.

[4]Garrett, loc. cit., p. 449.

[5]Ibid., p. 53.

[6]Ibid., p. 191.

The reliability of the difference between two means was computed by the formula for the standard error of the mean difference according to Clarke.[7]

The critical ratio or small t was calculated according to Garrett[8] and the table of t was used to determine the significance of the statistics.[9]

The data was analyzed in the above manner and conclusions were drawn from the obtained results.

Appendix A contains the complete data for each subject. This includes the three stop-watch times and their mean for each subject in the Control Group and Experimental Groups I and II on the pre-test and re-test (see pages 44 to 50). Appendix B contains the analyzed data used to equate each of the three groups. This includes the standard deviation and the standard error of the mean for the Control Group and Experimental Groups I and II on the pre-test and re-test (see pages 51 to 60). Appendix C contains the analyzed data for between group comparisons on the pre-test (see pages 61 to 64). Appendix D contains the analyzed data for within group comparisons (see pages 65 to 71). Appendix E contains between group analyses on the re-test (see pages 72 to 75).

---

[7]H. Harrison Clarke, loc. cit., p. 449.

[8]Garrett, loc. cit., p. 191.

[9]Ibid., p. 449.

CHAPTER IV

ANALYSIS OF DATA

This study was undertaken to determine the changes elicited by the use of hand weights during sprint training. Further, an attempt was made to determine if there were any significant differences resulting from a sprint training program which employed hand weights and a sprint training program which did not. An equated control group was utilized for reference with respect to a decrease in speed performance in the 50-yard dash. This control group was engaged in a required program of activities not related to this study.

The following results were obtained by an analysis of the data collected in this study.

Between-Group Comparisons of the Pre-test

The t technique for testing the significance of the difference between the means was applied to the total running times for the Control Group, Experimental Group I, and Experimental Group II on the pre-test. The results were used to determine if the groups were similar and could be considered equated.

On the pre-test the Control Group had a mean time of 6.57 seconds and a standard deviation of .346 seconds. The mean time for Experimental Group I on the pre-test was 6.56 seconds with a standard deviation of .310 seconds. The mean difference was .01 seconds, and the standard error of the mean difference for these two groups was .122 seconds. The critical ratio or t value was .082 which was not significant at the .01 level of confidence. The observed difference was considered to be due to chance, and the Control Group and Experimental Group I were considered equated (see Table 1, page 32).

Experimental Group II had a mean time of 6.53 seconds and a standard deviation of .307 seconds. With this data compared with the Control Group data, the difference between means was found to be .04 seconds and the standard error of the mean difference for these two groups was .23 seconds. This resulted in a critical ratio or t value of .325 which was not significant at the .01 level of confidence. The observed difference was considered to be due to chance and the Control Group and Experimental Group II were considered equated (see Table 1, page 32).

The data from the pre-test for Experimental Group I and Experimental Group II resulted in a standard error of the mean difference of .115 seconds, with a difference between means of .03 seconds. These data resulted in a critical ratio or t value of .262 which was not significant at the .01 level of confidence. The observed difference was considered to be due to chance and Experimental Group I and Experimental Group II were considered to be equated (see Table 1, page 32).

As a result of equating procedures and a test of significance on the pre-test, it was believed that the three groups were comparable at the beginning of the experimental period.

TABLE 1

BETWEEN-GROUP MEAN COMPARISONS OF THE PRE-TEST

Group Means	Mean Difference (Between Groups)	Standard Error	t value	Level of Confidence
Control Group 6.57 seconds Experimental Group I 6.56 seconds	.01	.122	.082	Not significant at .01 level
Control Group 6.57 seconds Experimental Group II 6.53 seconds	.04	.123	.325	Not significant at .01 level
Experimental Group I 6.56 seconds Experimental Group II 6.53 seconds	.03	.115	.262	Not significant at .01 level

Results of With-in Group Comparisons

After the completion of the re-test, the t technique for testing the significance of the difference between the means was applied to the pre-test, re-test data of each group. The results were used to determine if there were any significant changes in running time for 50-yards as a result of the experimental period.

The Control Group had a mean difference of .25 seconds between the pre-test and re-test. The mean score on the pre-test was 6.57 seconds, and the re-test mean was 6.32 seconds. The estimate of sampling error of the mean difference was .078. This resulted in a critical ratio of 3.27 with 13 degrees of freedom which indicated significance at the .01 level of confidence. The null hypothesis was rejected (see Table 2, page 34).

On the fifty yard dash, Experimental Group I had a mean score of 6.56 seconds on the pre-test and a mean score of 6.32 seconds on the re-test, resulting in a mean difference of .24 seconds. The estimate of sampling error of the mean difference was .059, which resulted in a critical ratio of 4.00 with 14 degrees of freedom. The t table showed that this t value was significant at the .01 level and the null hypothesis was rejected (see Table 2, page 34).

Experimental Group II had a mean score of 6.53 seconds on the pre-test and a mean score of 6.22 seconds on the re-test which resulted in a mean difference of .31 seconds. The estimate of sampling error of the mean difference was .044. This resulted in a critical ratio of 7.05 with 13 degrees of freedom. This critical ratio was significant at the .01 level of confidence and the null hypothesis was rejected (see Table 2, page 34).

TABLE 2

WITH-IN GROUP MEAN COMPARISONS ON
THE PRE-TEST AND RE-TEST

Group	Mean Difference (Pre-test Re-test)	Standard Error	t Value	Level of Significance
Control Group	.25 (seconds)	.078	3.27	Significant at .01 level
Experimental Group I	.24 (seconds)	.059	4.00	Significant at .01 level
Experimental Group II	.31 (seconds)	.044	7.05	Significant at .01 level

After the t technique for testing the significance of the difference between the mean had been employed, it was believed that each of the three groups had made speed increases which were significant at the .01 level of confidence.

Between-Group Comparisons of the Re-test

After it had been found that all three groups made significant decreases in speed performance at the .01 level of confidence, the investigator found it necessary to determine if there were any significant differences between the groups in regard to these increases in running time.

On the re-test the Control Group had a mean score of 6.32 seconds and a standard deviation of .307 seconds. The mean for Experimental Group I on the re-test was 6.32 seconds with a standard deviation of .256 seconds. The standard error of the mean difference for these two groups was .105 seconds. The means were equal at 6.32 seconds which resulted in a critical ratio or t value of .000. This critical ratio was not significant at the .01 level of confidence and the null hypothesis was retained (see Table 3, page 36).

Experimental Group II had a mean score of 6.22 seconds and a standard deviation of .206 seconds on the re-test. With this data compared with the Control Group data, the standard error of the mean difference was .098 seconds. With a difference of .10 seconds between means, the critical ratio or t value equalled 1.02 which was not significant at the .01 level of confidence. The null hypothesis was retained (see Table 3, page 36).

The data from the re-test on Experimental Group I and Experimental Group II resulted in a standard error of the mean difference of .086 seconds, and a difference between means of .10 seconds. These data resulted in a critical ratio of 1.16 which was not significant at the .01 level of confidence. The null hypothesis was retained (see Table 3, page 36).

As a result of the between groups comparison of the re-test results, it was believed that there were no significant differences between the three groups in regard to improved speed performance as a result of the experimental period.

TABLE 3

BETWEEN-GROUP MEAN COMPARISONS ON THE RE-TEST

Group Means	Mean Difference (Between Groups)	Standard Error	t value	Level of Confidence
Control Group 6.32 seconds Experimental Group I 6.32 seconds	.00	.105	.000	Not Significant at .01 level
Control Group 6.32 seconds Experimental Group II 6.22 seconds	.10	.098	1.02	Not Significant at .01 level
Experimental Group I 6.32 seconds Experimental Group II 6.22 seconds	.10	.086	1.16	Not Significant at .01 level

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

In this study, forty-three University of North Dakota freshman male students were equated into three groups, based on the results of a pre-test for running speed of one 50-yard dash. The three groups used in this study were a control group and two experimental groups. The control group took part in the testing phases of the study but did not participate in any of the sprint training program. Experimental Groups I and II participated in exactly the same sprint training program with the only difference being the use of three pound hand weights attached to each wrist of the subjects in Experimental Group II.

Each group was tested prior to and at the end of a six week training program. The tests were 50-yard dashes using three stop-watches calibrated in tenths of a second to time each subject. The three stop-watch times of each subject were averaged, thus establishing a mean time for each individual. The mean time of these three stop-watches was considered to be the sprinting time for that particular test. The test results were analysed for the following purposes:

1. To compare the performance of the three groups on the pre-test to determine whether or not the groups were similar and could be considered equated.

2. To compare pre-test performance with that of the performance on the re-test for each group to determine any significant changes in running speed.

3. To compare the performance of the three groups on the re-test to determine whether or not the changes in speed performance were significantly different between the groups.

Comparisons were made between the mean differences within each group as indicated by the pre-test and re-test. The significance of difference between the pre-test and re-test within each group was tested by the t technique for testing the significance of the difference between means derived from correlated scores from small samples.

Comparisons were then made between groups to establish whether or not the differences in performance were of a significant nature. For this purpose the t technique for testing the significance of the difference between the means was used. This test determines the ratio between the mean difference and the sampling error of the difference.

Conclusions

The following conclusions were believed justified by the analysis of data obtained in this study:

1. The results of this study indicate that the Control Group and Experimental Groups I and II made significant improvement at the .01 level of confidence in running speed during the experimental period as measured by the 50-yard dash.

2. Although all three groups improved their running times in the 50-yard dash significantly at the .01 level of confidence, there was no significant difference between the improvements each of these groups made.

3. The analyses of data indicated critical ratios or t scores for the Control Group of 3.27, Experimental Group I of 4.00, and Experimental Group II of 7.05. From these critical ratios it can be assumed that Experimental Group II improved more than Experimental Group I, and that Experimental Group I improved more than the Control Group, even though the improvements for each of these groups is significant at the .01 level of confidence.

4. The sprint training program which employed hand weights had no apparent deleterious effects on the subjects of Experimental Group II.

Recommendations

The following recommendations were made as a result of this study:

1. A similar study should be made using a longer training period and larger samples.

2. An investigation should be made to determine the psychological effects of wearing weighted equipment.

3. A study should be made to discover if gains in areas beneficial to other sports could be made by using hand weights.

4. Additional studies should be undertaken to determine the most feasible, yet most advantageous amount of weight to be used in each hand weight.

5. A more reliable method of measuring running speed could be used in a further study to determine more accurately differences in speed performance.

6. A similar study should be made where subjects are tested at a longer distance. This may prove to be a better test of speed.

7. A similar study should be conducted in which the subjects are placed into their respective groups by using the matching of pairs technique. Building in a relationship between groups can make possible the computation of a coefficient of correlation which can be used for more accurate testing of significance.

BIBLIOGRAPHY

Books

Bresnahan, George T., Tuttle, W. W., and Cretzmeyer, Francis X. Track and Field Athletics. St. Louis: The C. V. Mosby Co., 1960.

Bunn, John W. Scientific Principles of Coaching. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962.

Clark, H. Harrison. Application of Measurement to Health and Physical Education. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961.

Ecker, Tom (ed). Championship Track and Field. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961.

Garrett, Henry E. Statistics in Psychology and Education. New York: Longmans, Green and Co., 1958.

McNemar, Quinn. Psychological Statistics. New York: John Wiley and Sons, Inc., 1949.

Mortensen, Jesse P. and Cooper, John M. Track and Field For Coach and Athlete. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1959.

Ross, C. C. and Stanley, Julian C. Measurement in Today's Schools. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963.

Articles and Periodicals

Anonymous. "Track in the High Schools," Athletic Journal, XXVII (February, 1947), p. 26.

Capen, Edward. "The Effects of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, XXI (May, 1950), pp. 83-93.

Chui, Edward F. "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, XXI (May, 1950), pp. 188-194.

Chui, Edward F. "Effects of Isometric and Dynamic Weight-Training Exercises Upon Strength and Speed of Movement." Research Quarterly, XXXV (October, 1964), pp. 246-257.

Dintiman, George. "Effects of Various Trai[illegible] [illegible]rograms on Running Speed," Research Quarterly, XXXV (December, [illegible]), pp. 456-463.

Hanke, Al. "Weight Vests for Improving Track Athletes," Athletic Journal, XLII (December, 1961), p. 30.

Jesse, John P. "A New Look at Strength Development in Track and Field Athletes," The Physical Educator, XXII (May, 1965), p. 72.

Masley, John W. "Weight Training in Relation to Strength, Speed and Coordination," Research Quarterly, XXIV (October, 1953), pp. 308-315.

Nelson, Bert. "Of People and Things," Track and Field News, XIII (February, 1960), p. 10.

Russell, William W. "National Honor Roll," Athletic Journal, XLIV (January, 1964), p. 37.

Terlazzo, Tony. "What is Weight Training?" Physical Power (March-April, 1960), p. 8.

Walters, Etta C. "Scientific Foundations of the Overload Principle," Scholastic Coach, XXVII (March, 1958), p. 20.

Wilkin, Bruce M. "The Effect of Weight Training on Speed of Movement," Research Quarterly, XXIII (October, 1952), pp. 361-369.

Zorbas, William S. and Karpovich, Peter V. "The Effects of Weight Lifting Upon the Speed of Muscular Contractions," Research Quarterly, XXII (May, 1951), pp. 145-148.

Unpublished Material

Anderson, Kenneth A. "The Effect of the Weighted Ankle Spat on the Jumping Performance, Agility, and Endurance of High School Basketball Players." Unpublished Master's Thesis, University of Wisconsin, 1961.

Burnham, Stan. "Circuit Training." Unpublished Research Paper, Department of Physical Education, University of Texas, no date.

Dickinson, A. D. "A Study of the Relationship Between Foot Spacing, Starting Time, Speed in Sprinting, and Physical Measures." Unpublished Master's Thesis, State University of Iowa, 1933.

Fishbain, Jerome. "The Effects of a Nine-Week Training Program Upon Measures of Dynamic Strength of Adolescent Males." Unpublished Master's Thesis, University of Wisconsin, 1960.

Helixon, Patrick. "The Effects of Progressive Heavy Resistance Exercises Using Near-Maximum Weights on the Running and Jumping Ability of First-Year High School Track Performers." Unpublished Master's Thesis, University of Wisconsin, 1961.

Lukas, D. Wayne. "The Effect of a Weighted Training Shoe on the Jumping Performance, Agility, Running Speed, and Endurance of College Basketball Players." Unpublished Master's Thesis, University of Wisconsin, 1960.

Meisel, Stephen Gaylor. "The Effect of a Weight Training Program on the Speed of Running." Unpublished Master's Thesis, Pennsylvania State University, 1957.

Simpson, Wayne F. "The Effect of In-Season Use of Weighted Equipment on Speed, Endurance, Agility, and Power of High School Football Players." Unpublished Master's Thesis, University of North Dakota, 1963.

Tait, George Thomas. "The Effect of Wearing Ten-Pound Training Jackets on the Development of Endurance Running." Unpublished Master's Thesis, Pennsylvania State University, 1961.

Vanyo, Raymond J. "Weight Training Concentrated on the Arms and Shoulders and Its Effect Upon Speed of Junior High School Boys in the Sixty Yard Dash." Unpublished Master's Thesis, University of North Dakota, 1963.

Woodall, Thomas. "Weight Training of the Arms and Upper Body and Its Effect Upon Speed in High School Boys in the 100-Yard Dash." Unpublished Master's Thesis, Colorado State College, 1960.

THE THREE STOP-WATCH TIMES AND THEIR MEAN
FOR THE CONTROL GROUP ON THE PRE-TEST

Subject	Stop Watch A	Stop Watch B	Stop Watch C	Mean Time
1	6.00	6.00	6.00	6.00
2	6.20	6.10	6.10	6.13
3	6.40	6.20	6.20	6.26
4	6.30	6.20	6.30	6.26
5	6.50	6.30	6.20	6.33
6	6.50	6.40	6.40	6.43
7	6.70	6.60	6.70	6.66
8	6.70	7.00	6.60	6.76
9	6.80	6.70	6.90	6.80
10	6.80	6.80	6.80	6.80
11	6.80	6.80	6.80	6.80
12	6.70	6.80	7.00	6.83
13	6.90	6.90	6.90	6.90
14	7.10	7.20	6.90	7.06
Group Mean	....	....	....	6.57

THE THREE STOP-WATCH TIMES AND THEIR MEAN
FOR THE CONTROL GROUP ON THE RE-TEST

Subject	Stop Watch A	Stop Watch B	Stop Watch C	Mean Time
1	5.90	5.90	5.90	5.90
2	6.00	6.00	6.00	6.00
3	6.20	6.00	6.00	6.06
4	5.90	6.10	6.20	6.06
5	6.50	6.90	6.20	6.53
6	6.50	6.20	6.40	6.36
7	6.20	5.90	6.20	6.10
8	6.10	6.00	6.00	6.03
9	6.30	6.00	6.50	6.26
10	7.10	7.00	7.00	7.03
11	6.80	6.20	6.60	6.53
12	6.30	6.40	6.40	6.36
13	6.80	6.20	6.80	6.60
14	6.70	6.60	6.60	6.63
Group Mean	....	....	....	6.32

THE THREE STOP-WATCH TIMES AND THEIR MEAN FOR EXPERIMENTAL GROUP I ON THE PRE-TEST

Subject	Stop Watch A	Stop Watch B	Stop Watch C	Mean Time
1	6.20	6.00	6.00	6.06
2	6.10	6.10	6.20	6.13
3	6.30	6.20	6.00	6.16
4	6.40	6.30	6.20	6.30
5	6.20	6.50	6.40	6.36
6	6.50	6.40	6.50	6.46
7	6.60	6.30	6.50	6.45
8	6.50	6.50	6.50	6.50
9	6.70	6.80	6.50	6.66
10	6.60	6.80	6.70	6.70
11	6.70	6.80	6.90	6.80
12	6.90	6.80	7.00	6.90
13	6.90	6.90	7.00	6.93
14	6.90	6.90	7.10	6.96
15	6.90	7.00	7.20	7.03
Group Mean	....	....	....	6.56

THE THREE STOP-WATCH TIMES AND THEIR MEAN FOR
EXPERIMENTAL GROUP I ON THE RE-TEST

Subject	Stop Watch A	Stop Watch B	Stop Watch C	Mean Time
1	6.20	6.00	6.00	6.06
2	5.90	5.90	6.00	5.95
3	6.20	6.20	6.00	6.13
4	6.20	6.10	6.00	6.10
5	6.20	6.30	6.10	6.20
6	7.00	6.60	6.70	6.76
7	6.30	6.30	6.20	6.26
8	6.00	6.00	6.00	6.00
9	6.30	6.30	6.40	6.33
10	6.50	6.40	6.50	6.46
11	6.50	6.60	6.50	6.53
12	6.50	6.30	6.30	6.36
13	6.50	6.20	6.20	6.30
14	6.80	6.70	6.60	6.70
15	6.70	6.80	6.70	6.73
Group Mean	....	....	....	6.32

THE THREE STOP-WATCH TIMES AND THEIR MEAN FOR EXPERIMENTAL GROUP II ON THE PRE-TEST

Subject	Stop Watch A	Stop Watch B	Stop Watch C	Mean Time
1	6.10	6.10	6.10	6.10
2	6.10	6.10	6.10	6.10
3	6.30	6.10	6.10	6.16
4	6.30	6.30	6.20	6.26
5	6.50	6.40	6.20	6.36
6	6.30	6.40	6.50	6.40
7	6.40	6.50	6.50	6.46
8	6.50	6.50	6.50	6.50
9	6.40	6.80	6.80	6.66
10	6.60	6.90	6.60	6.70
11	6.80	6.80	6.80	6.80
12	6.90	6.90	6.90	6.90
13	7.00	6.90	7.00	6.96
14	7.10	6.90	7.10	7.03
Group Mean	....	....	....	6.53

THE THREE STOP-WATCH TIMES AND THEIR MEAN FOR
EXPERIMENTAL GROUP II ON THE RE-TEST

Subject	Stop Watch A	Stop Watch B	Stop Watch C	Mean Time
1	6.10	6.00	5.80	5.96
2	6.00	6.00	5.90	5.96
3	6.00	6.00	6.00	6.00
4	6.10	6.10	6.00	6.06
5	6.20	6.20	6.50	6.30
6	6.10	6.20	6.00	6.10
7	6.20	6.00	6.00	6.06
8	6.30	6.20	6.20	6.23
9	6.40	6.30	6.40	6.36
10	6.30	6.20	6.20	6.23
11	6.40	6.20	6.40	6.33
12	6.40	6.30	6.50	6.40
13	6.50	6.30	6.20	6.33
14	6.70	6.80	6.70	6.73
Group Mean	....	....	....	6.22

TOTAL DATA FOR EQUATING THE CONTROL GROUP

	Pre-Test		Re-Test	
Subject	X	X^2	X	X^2
1	6.00	36.0000	5.90	34.8100
2	6.13	37.5769	6.00	36.0000
3	6.26	39.1876	6.06	36.7236
4	6.26	39.1876	6.06	36.7236
5	6.33	40.0689	6.53	42.6409
6	6.43	41.3449	6.36	40.4496
7	6.66	44.3556	6.10	37.2100
8	6.76	45.6976	6.03	36.3609
9	6.80	46.2400	6.26	39.1876
10	6.80	46.2400	7.03	49.4209
11	6.80	46.2400	6.53	42.6409
12	6.83	46.6489	6.36	40.4496
13	6.90	47.6100	6.60	43.5600
14	7.06	49.8436	6.63	43.9569
ΣX	92.02		88.45	
ΣX^2		606.2416		560.1345

THE CONTROL GROUP STANDARD DEVIATION AND STANDARD ERROR OF THE MEAN ON THE PRE-TEST

$N = 14$

$\Sigma X = 92.02$

$\Sigma X^2 = 606.8416$

$$\sigma = \sqrt{\frac{N \Sigma X^2 - (\Sigma X)^2}{N}}$$

$$= \sqrt{\frac{14 \cdot 606.8416 - (92.02)^2}{14}}$$

$$= \sqrt{\frac{8487.3824 - 8467.6804}{14}}$$

$$= \sqrt{\frac{19.7020}{14}}$$

$$= \sqrt{19.7020} = 4.4386$$

$$= \frac{4.4386}{14}$$

$$= .346$$

$\sigma = .346$

$$S.E._m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{.346}{\sqrt{14}}$$

$$= \frac{.346}{3.742}$$

$$= .092$$

THE CONTROL GROUP STANDARD DEVIATION AND STANDARD ERROR OF THE MEAN ON THE RE-TEST

$N = 14$

$\Sigma X = 88.45$

$\Sigma X^2 = 560.1345$

$$\sigma = \sqrt{\frac{N \Sigma X^2 - (\Sigma X)^2}{N}}$$

$$= \sqrt{\frac{14 \cdot 560.1345 - (88.45)^2}{14}}$$

$$= \sqrt{\frac{7841.8830 - 7823.4025}{14}}$$

$$= \sqrt{\frac{18.4805}{14}}$$

$$= \sqrt{18.4805} = 4.2988$$

$$= \frac{4.2988}{14}$$

$$= .307$$

$$S.E._m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{.307}{\sqrt{14}}$$

$$= \frac{.307}{3.742}$$

$$= .082$$

TOTAL DATA FOR EQUATING EXPERIMENTAL GROUP I

	Pre-Test		Re-Test	
Subject	X	X^2	X	X^2
1	6.06	36.7236	6.06	36.7236
2	6.13	37.5769	5.95	35.4025
3	6.16	37.9456	6.13	37.5769
4	6.30	39.6900	6.10	72.2100
5	6.36	40.4496	6.20	38.4400
6	6.46	41.7316	6.76	45.6976
7	6.46	41.7316	6.26	39.1876
8	6.50	42.2500	6.00	36.0000
9	6.66	44.3556	6.33	40.0689
10	6.70	44.8700	6.46	41.7316
11	6.80	46.2400	6.53	42.6409
12	6.90	47.6100	6.36	40.4496
13	6.93	48.0249	6.30	39.6900
14	6.96	48.4416	6.70	44.8900
15	7.03	49.4209	6.73	45.2929
ΣX	98.41		94.87	
ΣX^2		647.0819		601.0021

THE STANDARD DEVIATION AND STANDARD ERROR OF THE MEAN ON THE PRE-TEST FOR EXPERIMENTAL GROUP I

$N = 15$

$\Sigma X = 98.41$

$\Sigma X^2 = 647.0819$

$$\sigma = \sqrt{\frac{N\Sigma X^2 - (\Sigma X)^2}{N}}$$

$$= \sqrt{\frac{15 \cdot 647.0819 - (98.41)^2}{15}}$$

$$= \sqrt{\frac{9706.2285 - 9684.5281}{15}}$$

$$= \sqrt{\frac{21.7004}{15}}$$

$$= \sqrt{21.7004} = 4.65$$

$$= \frac{4.65}{15}$$

$$= .310$$

$$S.E._m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{.310}{\sqrt{15}}$$

$$= \frac{.310}{3.873}$$

$$= .080$$

THE STANDARD DEVIATION AND STANDARD ERROR OF THE MEAN ON THE RE-TEST FOR EXPERIMENTAL GROUP I

$N = 15$

$\Sigma X = 94.87$

$\Sigma X^2 = 601.0021$

$$\sigma = \sqrt{\frac{N \Sigma X^2 - (\Sigma X)^2}{N}}$$

$$= \sqrt{\frac{15 \cdot 601.0021 - (94.87)^2}{15}}$$

$$= \sqrt{\frac{9015.0315 - 9000.3169}{15}}$$

$$= \sqrt{\frac{14.7146}{15}}$$

$$= \sqrt{14.7146} = 3.8359$$

$$= \frac{3.8359}{15}$$

$$= .256$$

$$S.E._m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{.256}{\sqrt{15}}$$

$$= \frac{.256}{3.873}$$

$$= .066$$

TOTAL DATA FOR EQUATING EXPERIMENTAL GROUP II

Subject	Pre-Test		Re-Test	
	X	X^2	X	X^2
1	6.10	37.2100	5.96	35.5216
2	6.10	37.2100	5.96	35.5216
3	6.16	37.9456	6.00	36.0000
4	6.26	39.1876	6.06	36.7236
5	6.36	40.4496	6.30	39.6900
6	6.40	40.9600	6.10	37.2100
7	6.46	41.7316	6.06	36.7236
8	6.50	42.2500	6.23	38.8129
9	6.66	44.3556	6.36	40.4496
10	6.70	44.8900	6.23	38.8129
11	6.80	46.2400	6.33	40.0689
12	6.90	47.6100	6.40	40.9600
13	6.96	48.4416	6.33	40.0689
14	7.03	49.4209	6.73	45.2929
ΣX	91.39		87.05	
ΣX^2		597.9025		541.8565

THE STANDARD DEVIATION AND STANDARD ERROR OF THE MEAN OF THE PRE-TEST FOR EXPERIMENTAL GROUP II

$N = 14$

$\Sigma X = 91.39$

$\Sigma X^2 = 597.9025$

$$= \sqrt{\frac{N\Sigma X^2 - (\Sigma X)^2}{N}}$$

$$= \sqrt{\frac{14 \cdot 597.9025 - (91.39)^2}{14}}$$

$$= \sqrt{\frac{8370.6350 - 8352.1321}{14}}$$

$$= \sqrt{\frac{18.5029}{14}}$$

$$= \sqrt{18.5029} = 4.30$$

$$= \frac{4.30}{14}$$

$$= .307$$

$$S.E._m = \frac{\quad}{\sqrt{N}}$$

$$= \frac{.307}{\sqrt{14}}$$

$$= \frac{.307}{3.742}$$

$$= .082$$

THE STANDARD DEVIATION AND STANDARD ERROR OF THE MEAN ON THE RE-TEST FOR EXPERIMENTAL GROUP II

$N = 14$

$\Sigma X = 87.05$

$\Sigma X^2 = 541.8565$

$$\sigma = \sqrt{\frac{N\Sigma X^2 - (\Sigma X)^2}{N}}$$

$$= \sqrt{\frac{14 \cdot 541.8565 - (87.05)^2}{14}}$$

$$= \sqrt{\frac{7585.9910 - 7577.7025}{14}}$$

$$= \sqrt{\frac{8.2885}{14}}$$

$$= \sqrt{8.2885} = 2.879$$

$$= \frac{2.879}{14}$$

$$= .206$$

$$S.E._m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{.206}{\sqrt{14}}$$

$$= \frac{.206}{3.742}$$

$$= .055$$

BETWEEN-GROUP COMPARISON ON THE PRE-TEST OF THE CONTROL GROUP AND EXPERIMENTAL GROUP I

$$S.E._d = \sqrt{(S.E._{m_1})^2 + (S.E._{m_2})^2}$$

$$= \sqrt{(.092)^2 + (.080)^2}$$

$$= \sqrt{.0085 + .0064}$$

$$= \sqrt{.0149}$$

$$= .122$$

$$d = m_1 - m_2$$

$$d = 6.57 - 6.56 = .01$$

$$t = \frac{d}{S.E._d}$$

$$= \frac{.01}{.122}$$

$$t = .082$$

$$df = (N_1 - 1) + (N_2 - 1)$$

$$= (14 - 1) + (15 - 1) = 27$$

t at .01 level = 2.77

Not significant at the .01 level

BETWEEN-GROUP COMPARISON ON THE PRE-TEST OF THE CONTROL GROUP AND EXPERIMENTAL GROUP II

$$S.E._d = \sqrt{(S.E._{m_1})^2 + (S.E._{m_2})^2}$$

$$= \sqrt{(.092)^2 + (.082)^2}$$

$$= \sqrt{.0085 + .0067}$$

$$= \sqrt{.0152}$$

$$= .123$$

$$d = m_1 - m_2$$

$$d = 6.57 - 6.53 = .04$$

$$t = \frac{d}{S.E._d}$$

$$= \frac{.04}{.123} =$$

$$t = .325$$

$$df = (N_1 - 1) + (N_2 - 1)$$

$$= (14 - 1) + (14 - 1) = 26$$

t at .01 level = 2.78

Not significant at the .01 level

BETWEEN-GROUP COMPARISON ON THE PRE-TEST OF EXPERIMENTAL GROUP I AND EXPERIMENTAL GROUP II

$$S.E._d = \sqrt{(S.E._{m_1})^2 + (S.E._{m_2})^2}$$

$$= \sqrt{(.080)^2 + (.082)^2}$$

$$= \sqrt{.0064 + .0067}$$

$$= \sqrt{.0131}$$

$$= .115$$

$d = m_1 - m_2$

$d = 6.56 - 6.53 = .03$

$$t = \frac{d}{S.E._d}$$

$$= \frac{.03}{.115}$$

$t = .262$

$df = (N_1 - 1) + (N_2 - 1)$

$= (15 - 1) + (14 - 1) = 27$

t at .01 level = 2.77

Not significant at the .01 level

COMPARISON OF THE CONTROL GROUP PRE-TEST, RE-TEST

Subject	Pre-Test	Re-Test	D	D^2
1	6.00	5.90	.10	.0100
2	6.13	6.00	.13	.0169
3	6.26	6.06	.20	.0400
4	6.26	6.06	.20	.0400
5	6.33	6.53	(-.20)	.0400
6	6.43	6.36	.07	.0049
7	6.66	6.10	.56	.4136
8	6.76	6.03	.73	.5329
9	6.80	6.26	.54	.2916
10	6.80	7.03	(-.23)	.0529
11	6.80	6.53	.27	.0729
12	6.83	6.36	.47	.2209
13	6.90	6.60	.30	.0900
14	7.06	6.63	.43	.1849
			$\Sigma D = 3.57$	$\Sigma D^2 = 2.0115$

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES FOR THE CONTROL GROUP

$N = 14$

$\Sigma D = 3.57$

$\Sigma D^2 = 2.0115$

$S_{\overline{D}}$ estimate of sampling error of $\overline{D} = \dfrac{S_D}{\sqrt{N}} = \dfrac{\sqrt{\dfrac{D^2 - \dfrac{(D)^2}{N}}{N-1}}}{\sqrt{N}}$

$$\frac{\sqrt{\dfrac{2.0115 - \dfrac{12.7449}{14}}{13}}}{3.742}$$

$$= 2.0115 - \frac{12.7449}{14} = 1.1011$$

$$= \frac{1.1011}{13} = .0847$$

$$= \sqrt{.0847} = .291$$

$$S_{\overline{D}} = \frac{.291}{3.742} = .078$$

$$\overline{D} = (\text{Mean difference}) = \frac{3.57}{14} = 2.55$$

$$t = \frac{\overline{D}\ (\text{Mean difference})}{S_{\overline{D}}\ (\text{estimate of sampling error of } \overline{D})} = \frac{.255}{.078} = 3.27$$

$df = N-1 = 13$

t at .01 level = 3.012

Significant at .01 level

COMPARISON OF EXPERIMENTAL GROUP I PRE-TEST, RE-TEST

Subject	Pre-Test	Re-Test	D	D^2
1	6.06	6.06	.00	.0000
2	6.13	5.95	.18	.0324
3	6.16	6.13	.03	.0009
4	6.30	6.10	.20	.0400
5	6.36	6.20	.16	.0256
6	6.46	6.76	(-.30)	.0900
7	6.46	6.26	.20	.0400
8	6.50	6.00	.50	.2500
9	6.66	6.33	.33	.1089
10	6.70	6.46	.24	.0576
11	6.80	6.53	.27	.0729
12	6.90	6.36	.54	.2916
13	6.93	6.30	.63	.3969
14	6.96	6.70	.26	.0676
15	7.03	6.73	.30	.0900
			$\Sigma D = 3.54$	$\Sigma D^2 = 1.5644$

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES FOR EXPERIMENTAL GROUP I

$N = 15$

$\Sigma D = 3.54$

$\Sigma D^2 = 1.5644$

$S_{\overline{D}}$ estimate of sampling error of $\overline{D} = \dfrac{S_D}{\sqrt{N}} = \dfrac{\sqrt{\dfrac{D^2 - \dfrac{(D)^2}{N}}{N-1}}}{\sqrt{N}}$

$$\frac{\sqrt{\dfrac{1.5644 - \dfrac{12.5316}{15}}{14}}}{3.873}$$

$$= 1.5644 - \frac{12.5316}{15} = .7290$$

$$= \frac{.7290}{14} = .052$$

$$= \sqrt{.052} = .228$$

$$S_{\overline{D}} = \frac{.228}{3.873} = .059$$

$$\overline{D} = \text{(Mean difference)} = \frac{3.54}{15} = .236$$

$$t = \frac{\overline{D}\ \text{(Mean difference}}{S_{\overline{D}}\ \text{(estimate of sampling error of } \overline{D})} = \frac{.236}{.059} = 4.00$$

$df = N-1 = 15-1 = 14$

t at .01 level = 2.977

Significant at .01 level

COMPARISON OF EXPERIMENTAL GROUP II PRE-TEST, RE-TEST

Subject	Pre-Test	Re-Test	D	D^2
1	6.10	5.96	.14	.0196
2	6.10	5.96	.14	.0196
3	6.16	6.00	.16	.0256
4	6.26	6.06	.20	.0400
5	6.36	6.30	.06	.0036
6	6.40	6.10	.30	.0900
7	6.46	6.06	.40	.1600
8	6.50	6.23	.27	.0729
9	6.66	6.36	.30	.0900
10	6.70	6.23	.47	.2209
11	6.80	6.33	.47	.2209
12	6.90	6.40	.50	.2500
13	6.96	6.33	.63	.3969
14	7.03	6.73	.30	.0900
			$\Sigma D = 4.34$	$\Sigma D^2 = 1.7000$

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES FOR EXPERIMENTAL GROUP II

$N = 14$

$\Sigma D = 4.34$

$\Sigma D^2 = 1.7000$

$S_{\overline{D}}$ estimate of sampling error of $\overline{D} = \frac{S_D}{\sqrt{N}} = \frac{\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}}}{\sqrt{N}}$

$$\frac{\sqrt{\frac{1.7000 - \frac{18.8356}{14}}{13}}}{3.742}$$

$$= 1.7000 - \frac{18.8356}{14} = .3546$$

$$= \frac{.3546}{13} = .0273$$

$$= \sqrt{.0273} = .165$$

$$S_{\overline{D}} = \frac{.165}{3.742} = .044$$

$\overline{D}$ = (Mean difference) = $\frac{4.34}{14} = .310$

$$t = \frac{\overline{D}\ \text{(Mean difference)}}{S_{\overline{D}}\ \text{(estimate of sampling error of } \overline{D})} = \frac{.31}{.044} = 7.05$$

df = N-1 = 13

t at .01 level = 3.012

Significant at .01 level

BETWEEN-GROUP COMPARISON ON THE RE-TEST OF THE CONTROL GROUP AND EXPERIMENTAL GROUP I

$$S.E._d = \sqrt{(S.E._{m_1})^2 + (S.E._{m_2})^2}$$

$$= \sqrt{(.082)^2 + (.066)^2}$$

$$= \sqrt{.0067 + .0044}$$

$$= \sqrt{.0111}$$

$$= .105$$

$$d = m_1 - m_2$$

$$= 6.32 - 6.32 = .00$$

$$t = \frac{d}{S.E._d}$$

$$= \frac{.00}{.105}$$

$$t = .000$$

$$df = (N_1 - 1) + (N_2 - 1)$$

$$= (14-1) + (15-1) = 27$$

t at .01 level = 2.77

Not significant at the .01 level

BETWEEN-GROUP COMPARISON ON THE RE-TEST OF THE CONTROL GROUP AND EXPERIMENTAL GROUP II

$$S.E._d = \sqrt{(S.E._{m_1})^2 + (S.E._{m_2})^2}$$

$$= \sqrt{(.082)^2 + (.055)^2}$$

$$= \sqrt{.0067 + .0030}$$

$$= \sqrt{.0097}$$

$$= .098$$

$$d = m_1 - m_2$$

$$= 6.32 - 6.22 = .10$$

$$t = \frac{d}{S.E._d}$$

$$= \frac{.10}{.098}$$

$$t = 1.02$$

$$df = (N_1-1) + (N_2-1)$$

$$= (14-1) + (14-1) = 26$$

t at .01 level = 2.78

Not significant at the .01 level

BETWEEN-GROUP COMPARISON ON THE RE-TEST OF EXPERIMENTAL GROUP I AND EXPERIMENTAL GROUP II

$$S.E._d = \sqrt{(S.E._{m_1})^2 + (S.E._{m_2})^2}$$

$$= \sqrt{(.066)^2 + (.055)^2}$$

$$= \sqrt{.0044 + .0030}$$

$$= \sqrt{.0074}$$

$$= .086$$

$$d = m_1 - m_2$$

$$= 6.32 - 6.22 = .10$$

$$t = \frac{d}{S.E._d}$$

$$= \frac{.10}{.086}$$

$$t = 1.16$$

$$df = (N_1 - 1) + (N_2 - 1)$$

$$= (15-1) + (14-1) = 27$$

t at .01 level = 2.77

Not significant at the .01 level