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A Comparison of Two Groups of College Men, Isometrically and Isotonically Trained, With Respect to Strength Retention

Richard N. Haugen

The thesis here abstracted, submitted by Richard N. Haugen 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.

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A COMPARISON OF TWO GROUPS OF COLLEGE MEN, ISOMETRICALLY AND ISOTONICALLY TRAINED, WITH RESPECT TO STRENGTH RETENTION

Richard N. Haugen, Master of Science

The thesis here abstracted was written under the direction of Walter C. Koenig and approved by John L. Quaday and Allyn W. Sturgis as members of the examining committee, of which Mr. Koenig was Chairman.

The purpose of this study was to determine the difference, if any, in the retention of strength obtained by taking part in a weight-training program of exercises as opposed to a program of isometric exercises.

The subjects selected for this study were freshman and sophomore male students at the University of North Dakota enrolled in the required physical education program. This selection was a random choice of one weight-training class and one isometric class. Both groups participated in their respective exercise programs for a period of eight weeks. At the end of the eight week training period, they participated in unrelated activities consisting of three weeks of slow-pitch softball and three weeks of golf.

Each group was tested relative to strength on four test items consisting of shoulder dips, back strength, leg strength, and forearm strength. These test items were administered at the beginning of the experimental period, after the eight weeks of training, and at the end of the six weeks of unrelated activity.

Comparisons were made between the mean differences within each group on each test item as indicated by the pre-test and

re-test, and the re-test and final test. The null hypothesis was assumed with respect to the differences within groups. This hypothesis was tested with the "t" technique for the difference between means derived from correlated scores from small samples. Comparisons were also made between the weight-training group and isometric group by testing the significance of the difference between the mean differences found within the groups. The between group comparison used the "t" technique for uncorrelated data from small samples.

Based on the results of this study, it seemed apparent that there were some differences in the retention of strength on test items within the groups. However, the treatment of the data with respect to the differences between the two groups indicated no significant difference at the .01 level of confidence.

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by

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CHAPTER I

THE PROBLEM AND ITS SCOPE

The Problem

The purpose of this study was to determine the difference, if any, in the retention of strength obtained by taking part in a weight-training program of exercises and a program of isometric exercises. Through this comparison of the effectiveness of different methods of attaining and maintaining physical strength and health, sounder application of these exercise programs may become possible.

The specific problems of this study were as follows:

1. To determine the strength levels of both groups in each test at the beginning of the experimental period.

2. To determine the strength increases of both groups in each test during the experimental period.

3. To determine the strength retention of both groups in each test six weeks after the close of the experimental period.

Need for the Study

It is no longer necessary for man to devote all of his time to the basic task of survival. Man's use of the forces of nature have liberated him, to a great degree, from the slavery of heavy

physical labor. Advances in technology and transportation now enable man to live a life of relative comfort and ease, free from the great expenditure of physical effort. However, man is the same organically, and the human body does not seem to have arrived at a state in which it remains functionally efficient in spite of inactivity and sedentary living. There is still a great need for strength.

It is generally known that a period of intense training will produce, among other things, an increase in strength in the muscles trained. Recently, weight-training has become a popular means of exercise used to develop strength. Such programs are a part of the required physical education courses offered at most universities and colleges. Although static contraction methods of gaining strength have been known for a great number of years, it is largely through the recent experimentation of the Germans, Hettinger and Muller,[1] that static contraction methods have become recognized as an extremely efficient method of strength development. Because strength is gained through specific training or vigorous activity, organic strength is frequently listed as an outcome or an objective of the physical education programs of various institutions. However, there seems to be little concern for, or precise knowledge about what happens

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[1]Th. Hettinger and E. A. Muller, Max-Planck Institut fur Arbeitsphysiologie, Dortmund, Germany, cited by James Lyne, "The Frequency of Static Contraction Exercise Necessary for Strength Level Maintenance," (Unpublished Master's thesis, Department of Physical Education, Pennsylvania State University, 1958) p.4.

to the strength that is developed once the training ceases. Most of the efforts in the investigations of strength have been devoted to strength development rather than strength maintenance or retention.

It has been somewhat widely accepted that upon termination of training, an individual's strength decreases or subsides to levels existing before the training began. It seems possible that experimentation in which the post-training strength levels of individuals are measured may yield knowledge and reveal new techniques in the area of strength development and retention. It is hoped that, through this study, some insight can be obtained in the area of strength retention following completion of isotonic and isometric programs of attaining strength increases.

Delimitations

This study was limited to University of North Dakota freshman and sophomore male students enrolled in the required physical education program. There were thirteen subjects in the isometric group and fourteen subjects in the weight-training group. The strength tests used were the shoulder dips on the parallel bars, back strength measured by a dynamometer, leg strength measured by a dynamometer, and forearm strength measured by a cable-tensiometer. These tests were administered at the beginning of the experimental period and at the end of the eighth week. These same tests were again administered after a six week period of participation in an unrelated activity. The experimental period was the second semester of the 1964-'65 school year.

Definitions

The Isometric Group consisted of thirteen male freshman and sophomore students, enrolled in the required physical education program at the University of North Dakota, that participated in isometric exercises for a period of eight weeks before taking part in an unrelated activity in which there were no isometric exercises.

The Weight-Training Group consisted of fourteen male freshman and sophomore students, enrolled in the required physical education program at the University of North Dakota, that participated in weight-training exercises for a period of eight weeks before taking part in an unrelated activity in which there were no weight training exercises.

The Isotonic Group is used interchangeably with the weight-training group throughout this study.

The Unrelated Activity consisted of golf and slow-pitch softball with the amount of time spent on each being equally divided.

Isotonic is a condition with muscles, in which the tension remains relatively constant during changes in muscle length.[2]

Isometric is a state of tension, in connection with muscles, in which the length of the muscle does not appreciably change.[3]

Weight-training consists of varied and numerous exercises performed by an individual with barbells and dumbells. The individual performs each exercise with numerous repetitions and sets.

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[2]Robert K. Jensen, "The Measurement of Maximum Average Muscle Power and Its Relationship to Maximum Isometric Length," (Unpublished Education thesis, Department of Physical Education, University of Western Australia, 1963) p. 6.

[3]Ibid., p. 6.

Dynamometer is a spring based instrument used for the measuring of force or power developed by an object.

Cable-tensiometer is a cable-tension type scale used for the measurement of muscular strength.

CHAPTER II

REVIEW OF RELATED LITERATURE AND RESEARCH

Introduction

The literature reviewed for this study has been divided into two sections. The first section is concerned with comparative studies of weight-training and isometrics in regard to their effects on strength gains, endurance and muscle girth. Studies have shown varying effects on these three items and in many instances, the studies contradict one another. The second section is devoted to studies that have been done on strength retention and maintenance. The studies in this section generally relate to the subject of this study. Some of the important findings on these two subjects have been summarized in this chapter.

Comparative Studies on Weight-Training and Isometrics

Marley,[1] in a study of the comparative effectiveness of isometric exercise and isotonic exercise in the development of muscular strength, endurance and girth, drew the following conclusions:

1. There is little difference in the effectiveness of isometric and isotonic exercises in the development of strength.

2. Isometric exercise is more effective in the development of isometric endurance.

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[1]William Paul Marley, "The Comparative Effectiveness of Isometric Exercise and Isotonic Exercise in the Development of Muscular Strength, Endurance, and Girth," (Unpublished Master's thesis, Department of Physical Education, University of Maryland, 1962) p. 82.

3. Isotonic exercise is more effective in the development of isotonic endurance.

4. Isometric exercise is more effective in the development of muscular size.

5. Isometric endurance and isotonic endurance appear to be separate physiological phenomena.

6. The strength of a muscle is not necessarily proportional to its girth as measured in this study.

In a similar study by Richardson,[2] where brief isometric and isotonic exercise programs were used, these conclusions were drawn:

1. The isotonic exercise group increased significantly over the isometric group at the 135 degree angle and both increased significantly over the control group.

2. The isotonic and isometric groups increased significantly in strength over the control group at the 115 degree angle. There was no statistically significant difference between the isometric and isotonic groups.

3. The muscular endurance holding time, when measured by using the same amount of weight on both the initial and final tests, showed a significant improvement for the combined isotonic and isometric group scores of the trained leg when compared to the control group.

4. The cross-transfer of strength was statistically significant for both isotonic and isometric exercise programs at both angles measured. There was no cross transfer of muscle endurance.

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[2]John R. Richardson, "The Effect of Brief Isometric and Isotonic Exercise Programmes on the Development of Strength and Muscular Endurance," (Unpublished Master's thesis, Department of Physical Education, University of Alberta, 1963) p. 86.

As the conclusions of the two previous studies are analyzed, both studies give indications that isotonic exercises are somewhat better in developing strength and endurance. However, these indications are contradicted in the next studies that are discussed.

Asa,[3] in a study on the effects of isometric and isotonic exercises on the strength of skeletal muscle, drew the following conclusions:

1. All subjects in all groups showed significant increase in muscle strength.

2. The group utilizing a single isometric exercise routine, showed a greater increase in strength than the increase which was achieved by the group utilizing isotonic progressive resistance exercise routine.

3. The group utilizing repetitive isometric exercise routine exceeded the former two groups in the gain of strength.

4. The group utilizing repetitive isometric exercise routine exhibited a higher level of endurance than the first two groups at the conclusion of the investigation.

5. There was no significant difference in the level of endurance exhibited between group A (isotonic) and group B (single isometric).

6. An effective manner to increase the strength and efficiency of skeletal muscle, in a relatively short period of time, is to submit it to a repetitive isometric exercise regimen while fixing the muscle in a position as close as possible to its natural resting length.

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[3]M. Maxim Asa, "The Effects of Isometric and Isotonic Exercises on the Strength of Skeletal Muscle," (Unpublished Doctors dissertation, Department of Physical Education, Springfield College, 1959) p. 114.

Sullivan[4] made a study at Washington State University to determine the effects of static and isotonic exercise of the quadriceps on strength and endurance. From this investigation the conclusions were:

1. Ten maximal isotonic contractions of the quadriceps twice weekly for a six-week period produced significant gains in strength and endurance, and a slight loss in knee joint flexibility.

2. Two consecutive six-second static contractions of the quadriceps twice weekly, for a six-week period, produced significant gains in strength and endurance, and significant loss in knee joint flexibility.

3. The subjects performing static exercise showed significantly better gains in strength than subjects performing isotonic exercises.

4. The subjects performing isotonic exercise showed significantly better gains in endurance than the subjects performing static exercise.

5. There was no significant hypertrophy of the quadriceps following either exercise regimen in this study.

As the conclusions of these two studies are analyzed, both give indications that isometric exercises are superior in developing strength. These contradictions bring out the point that a great deal more study is needed with the possibilities appearing to be endless.

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[4]George Morris Sullivan, "The Effects of Isotonic and Static Contraction of the Quadriceps on Strength and Endurance," (Unpublished Master's thesis, Department of Physical Education, Washington State University, 1961) p. 44.

Studies on Retention and Maintenance of Strength

The beneficial effects of physical exercise on the physiological systems of the body have been supported repeatedly by experimental evidence. In contrast, much less has been reported in the literature regarding what happens when training stops. It has been established, for example, that during the period following the cessation of training, strength decreases. There is also evidence that strength decreases at a slower rate if it has been acquired during a relatively longer period of training than if it has been gained during a shorter period.[5]

In 1958, Rarick and Larsen[6] reported a study which compared the effectiveness of a single daily six-second exercise bout in which two-thirds maximum tension was used with an exercise program involving more frequent bouts at eighty per cent maximum tension. They divided thirty high school boys into two experimental groups and one control group and conducted strength tests periodically during a four week period. The gains achieved by the two experimental groups at the end of the training period were significant beyond the .01 level of confidence. Loss in strength during the four week post-training period was significant for both groups at the .05 level of confidence.

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[5]E. A. Muller, "The Regulation of Muscular Strength," Journal of the Association of Physical and Mental Rehabilitation, Volume 9, (March, April 1957) pp. 41-47.

[6]Lawrence G. Rarick and Gene L. Larsen, "Observations on Frequency and Intensity of Isometric Muscular Effort in Developing Static Muscular Strength in Post-Pubescent Males," Research Quarterly, Volume 29, (October 1958) pp. 333-341.

The difference between the two experimental groups, while not significant, showed that the group which employed the higher tension level for longer periods of time, retained the most strength.

In a survey of the literature regarding isotonic and isometric exercises, Lyne[7] found that short periods of training will produce an increase in strength, and that static contraction exercises may be employed very advantageously as a means of gaining strength. Strength was usually found to decrease after the cessation of training. However, in most instances the level of strength, when measured following a period of inactivity, sometimes as long as a year, revealed a level higher than the original value recorded before the training. There are some indications that a longer time spent in the training may retard the rate of decline of strength, even if the total amount of exercise is the same in both cases.

Lyne[8] concluded from his study on strength maintenance that:

1. The strength level achieved rapidly during an eight-week session of weight-training declines after the cessation of that training.

2. Training once weekly with static contraction exercises--maximum exertion for six seconds per muscle group--significantly increases a newly acquired level achieved through eight weeks of weight-training.

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[7]Lyne, loc. cit., p. 25

[8]Lyne, loc. cit., pp. 62-63.

3. A newly acquired strength level, achieved during eight weeks of weight-training can be maintained by training with static contraction exercises once every week for an additional period of eight weeks.

4. Training with static contraction exercises once every three weeks for nine weeks following the achievement of a new strength level is not sufficient to maintain that strength level.

Hettinger and Muller used short periods of static muscular effort with tension levels maintained at two-thirds maximum isometric strength.[9] They reported that one daily exercise bout in which the subject maintained two-thirds maximal tension for six seconds was as effective in building strength as longer and more frequent periods of static exercise. The resulting gain in strength was approximately five per cent per week. With the termination of the training program, the investigators found that the loss of strength occurred at about the same rate as that achieved during training.[10]

"....we have found that static or isometric contractions must be practiced fortnightly to maintain strength gained through previous training. One contraction in three weeks could not prevent a slow fall in strength, while weekly contractions still have a training effect...."[11]

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[9]Th. Hettinger and E. A. Muller, "Muskelleistung and Muskeltraining," Internationale Zeitschrift fur Angewandte Physiologie (Arbeitsphusiologie) Volume 15, (1953) pp. 111-126, cited by James Lyne, "The Frequency of Static Contraction Exercise Necessary for Strength Level Maintenance," (Unpublished Master's thesis, Department of Physical Education, Pennsylvania State University, 1958) p. 5.

[10]Ibid

[11]Ibid, p. 69, quotation from a letter (Dr. E. A. Muller to James Lyne)

In a study on the changes in the physical status of varsity and freshman wrestlers at the University of Oregon following a six week cessation of organized team practices and competition, Hassman[12] found that the subjects showed a significant increase in elbow flexor strength following the six week cessation period. There was also a significant change in arm girth. Although the correlations between body weight and elbow flexor strength were significant in both the initial and final testings, the correlations between increases in body weight and elbow flexor strength were not significant. It therefore cannot be concluded, on the basis of these findings, that an increase in body weight was a factor in the increase of elbow flexor strength.[13]

Although many of the findings regarding physiological changes following discontinuance of training are not in agreement, there is a general belief among coaches and athletes that training should not be discontinued abruptly.

Pohndorf[14] stated, in a review of cholesterol studies, that keeping double calorie intake but discontinuing the exercise for three weeks during which they took part in the control level of activities, the subjects gained weight with a marked increase in serum cholesterol

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[12]Ralph P. Hassman, "Changes in the Physical Status of Varsity and Freshman Wrestlers at the University of Oregon Following a Six Week Cessation of Organized Team Practices and Competition," (Unpublished Ph.D. Dissertation, Department of Physical Education, University of Oregon, 1961) p. 63.

[13]Ibid

[14]R. H. Pohndorf, "Cholesterol Studies: A Review", Research Quarterly, Volume 29, (May 1958) p. 190.

levels. During this period the subjects became fat, their collars and belts became tight, complexion became sallow, and they complained of fitful hours of sleep.

From the review of literature, there is evidence that there are many variables, many varying findings, and many varying opinions in regard to strength maintenance and retention. There is little evidence, however, as to which type of exercise, isotonic or isometric, tends to enhance strength retention more.

CHAPTER III

PROCEDURE

The tests were administered in accordance with the recommendations and instructions of Professor Koenig, Department of Physical Education, University of North Dakota and a procedure described in Mathew's[1] Measurement in Physical Education. The method and procedure used in group selection, organization and supervision of the testing have been presented in this chapter.

Selection of Groups

The selection of the groups was a random choice of two physical education classes at the University of North Dakota. One group was known as the isometric group and the other was known as the weight-training group. The groups were not equated in any way.

Test Administration

The facilities of the University of North Dakota Physical Education Department were used for the administration of the tests. The shoulder dips were completed on the parallel bars in the apparatus room. The back strength and leg strength test was given in the research laboratory of the department. The order in which the tests were given was the same during each testing session as follows: (1) shoulder dips, (2) back strength, (3) leg strength, and (4) forearm strength. The choice of this order was a matter of convenience. The subjects were given

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[1]Donald K. Mathews, Measurement in Physical Education, (Philadelphia: W. B. Saunders Company, 1963) pp. 68-71.

instruction on the execution of each test each of the three times they were administered as follows:

1. Pre-test given at the beginning of the semester to determine the strength levels of the groups.

2. Retest given at the end of the eighth week to determine the attained strength levels of the groups.

3. Final test given at the end of the fourteenth week to determine the retention of strength after a six week period of participation in an unrelated activity.

Shoulder Dips

Equipment: A regular set of parallel bars set at approximately the shoulder height of the individual.

Procedure: The bars were gripped in a normal "handshake" grip with the individual standing on the floor. The subject mounted the bars, using his arms to raise himself to an erect position. The subject raised and lowered himself as many times as possible.

Rules: 1. The subject was given a credit of one for mounting the bars.

2. The subject dips to the point where the elbow forms a right angle. The examiner notes this point and the subject lowers himself to it each time he dips down.

3. A credit of one-half was given if the subject was unable to get all the way up. Only one of these half credits was counted and the test ended at this point.

4. Swinging was not allowed.

Scoring: The number of dips, to the nearest half, was recorded.

Back Strength

Equipment: The equipment for this test consisted of the dynamometer, two short chains with hooks attached, and a dynamometer base with a hook attached.

Procedure: The subject stood on the dynamometer base with feet parallel and about six inches apart. The ankle joint was as nearly opposite the attachment of the dynamometer to its base as possible. The subject stood with head erect, back straight, and chalked fingers extending down the thighs. The examiner held the bar at the tips of the subject's fingers to obtain proper adjustment. The bar was then connected to the chain. The subject bent slightly forward, with knees straight, and grasped the bar near either end with a pronated grip. The subject lifted straight up as hard as possible.

Rules: 1. One trial was allowed unless it was obvious that the subject did not execute the procedure properly.

2. The knees must remain straight.

3. The arms must remain straight; only the back exerts pressure.

Scoring: The pounds of pressure indicated on the dynamometer dial were recorded.

Leg Strength

Equipment: The equipment for this test consisted of the dynamometer, web belt, two short chains with hooks attached, and a dynamometer base with a hook attached.

Procedure: The subject assumed the same position as in the back lift. The web belt was used around the subject's hips to stabilize

the bar. The bar was grasped near its center with the palms of the hands in a pronated position. The subject, with head up and back straight, bent his knees so that an angle of 115 to 125 degrees was formed. The bar was on the subject's thighs during the lift. The pressure was exerted straight up and at the completion of the lift the subject's knee joints were almost completely extended to insure maximum effort.

Rules: 1. One trial was allowed unless it was obvious that the subject did not execute the procedure properly.

2. The starting position angle of the flexed knees must be within the prescribed limits.

3. The back must remain straight.

4. The arms must remain straight; only the legs exert pressure.

Scoring: The pounds of pressure indicated on the dynamometer dial were recorded.

Forearm Strength

Equipment: The equipment for this test consisted of a cable-tensiometer, a short chain, a short cable one-eighth inch in diameter, and a handle all of which were connected, and a table. In the center of the table was a hook that was used to attach the chain.

Procedure: The subject took a position on his knees with his dominant arm on top of the table resting on its elbow. The other arm was loosely extended at his side. The dominant arm was extended at an angle of approximately 120 to 135 degrees with the arm pit above the level of the table top. The subject gripped the handle of the cable

in his hand and the chain was attached to the hook on the table. The cable-tensiometer was attached to the cable and the dial set at zero. The pressure was exerted by flexing the forearm in a steady pull toward the body.

Rules: 1. One trial was allowed unless it was obvious that the subject did not execute the procedure properly.

2. The starting position angle of the flexed elbow must be within the prescribed limits.

3. Both knees must remain on the floor.

4. The non-dominant arm must remain loosely extended at the subject's side.

Scoring: The test was scored by taking the scale reading on the cable-tensiometer and converting it to pounds by using the Calibration Table that corresponds with the cable-tensiometer used in the test.

Statistical Procedure

This investigator assumed the null hypothesis in analyzing the differences between the means obtained on the initial test and the retest, and between the means obtained on the retest and the final s strength test. That hypothesis[2] asserts that there is no true difference between the two mean scores, and the difference found between the sample means is a chance difference and is accidental and unimportant. Investigation of several possible tests of the null hypothesis indicated

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

that 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. This test determines the ratio between the mean difference and the estimate of sampling error of the mean difference. This ratio is expressed as "t" and is checked for significance in a "t" table. The value of "t" is proportional to the degrees of freedom (N-1) allowed in determining the relationship between the mean difference and the estimate of sampling error of the mean difference.

For this study it was decided to reject the null hypothesis at the .01 level of significance.

Complete data including mean differences and raw scores are presented in Appendix A. Details of the mathematical process employed in the analysis for each testing area is presented in Appendix B.

CHAPTER IV

ANALYSIS OF THE DATA

The purpose of the testing in this study was to determine whether or not there were any significant differences in the retention of strength within groups and between the isotonic group as compared to the isometric group. The bases for comparison were the results obtained from the three tests used for measuring the levels of strength.

Results of Comparison

Shoulder Dips

The isometric group had a mean score of 10.6538 shoulder dips in the pre-test and a mean score of 16.2692 shoulder dips in the re-test which measured shoulder girdle strength and endurance. This represented a mean difference increase of 5.6154 between the pre-test and the re-test. The estimate of the sampling error of this mean difference was .346. The "t" value of 16.68 with 12 degrees of freedom indicated significance at the .01 level of confidence, and the null hypothesis was therefore rejected.

The isometric group had a mean score of 14.6538 on the final test which represented a mean difference decrease of 1.6454 from the re-test mean score. The estimate of the sampling error of this mean difference was .566. The "t" value of 2.853 with 12 degrees of freedom was not significant at the .01 level of confidence, and the null hypothesis was therefore retained.

The weight-training group had a mean score of 12.7142 shoulder dips in the pre-test and a mean score of 21.1428 shoulder dips in the re-test. This represented a mean difference increase of 8.4286 between the pre-test and the re-test. The estimate of the sampling error of this mean difference was .989. The "t" value of 8.866 with 13 degrees of freedom indicated significance at the .01 level of confidence, and the null hypothesis was therefore rejected.

The weight-training group had a mean score of 19.1071 on the final test which represented a mean difference of 2.0357 from the re-test mean score. The estimate of the sampling error of this mean difference was .39. The "t" value of 1.19 with 13 degrees of freedom was not significant at the .01 level of confidence, and the null hypothesis was therefore retained.

Both groups gained significantly in shoulder girdle strength during the eight weeks of training, and neither group lost significantly during the six weeks following cessation of training.

Back Strength

In the pre-test of back strength, the isometric group had a mean score of 319.2307 pounds; in the re-test this group had a mean score of 410.0 pounds. A mean difference increase of 90.7693 pounds between the pre-test and the re-test was shown. The estimate of the sampling error of this mean difference was 15.909. The "t" value of 6.271 with 12 degrees of freedom was significant at the .01 level of confidence, and the null hypothesis was therefore rejected.

The isometric group had a mean score of 373.4615 pounds on the final test which produced a mean difference decrease of 36.5385 pounds from the re-test mean score. The estimate of the sampling error of this mean difference was 10.732. The "t" value of 3.405 with 12 degrees of freedom indicated significance at the .01 level of confidence and the null hypothesis was therefore rejected.

The weight-training group had a mean score of 303.5714 pounds in the pre-test and a mean score of 350.0 pounds in the re-test. This was a mean score increase of 46.4286 pounds. The estimate of the sampling error of this mean difference was 14.764. The "t" value of 3.145 with 13 degrees of freedom indicated significance at the .01 level of confidence, and therefore the null hypothesis was rejected.

The weight-training group had a mean score of 323.9285 pounds on the final test which produced a mean difference decrease of 26.0715 pounds from the re-test mean score. The estimate of the sampling error of this mean difference was 9.334. The "t" value of 2.937 with 13 degrees of freedom was not significant at the .01 level of confidence, and the null hypothesis was therefore retained.

Both groups gained significantly in back strength during the eight weeks of training and the loss of strength by the weight-training group was not significant during the six weeks following cessation of training. The isometric group had a significant loss of strength during the six weeks following the cessation of training.

Leg Strength

The isometric group had a mean score of 554.6153 pounds in the pre-test and a mean score of 757.6923 pounds in the re-test. A mean difference increase of 203.077 pounds was shown. The estimate of the sampling error of this mean difference was 32.308. The "t" value of 6.2866 with 12 degrees of freedom indicated significance at the .01 level of confidence, and therefore the null hypothesis was rejected.

The isometric group had a mean score of 736.923 pounds on the final test which resulted in a mean difference decrease of 20.7693 pounds from the re-test mean score. The estimate of the sampling error of this mean difference was 25.218. The "t" value of .488 with 12 degrees of freedom was not significant at the .01 level of confidence, and the null hypothesis was therefore retained.

In the pre-test of leg strength, the weight-training group had a mean score of 377.5 pounds; in the re-test this group had a mean score of 570.0 pounds. A mean score difference increase of 192.5 pounds between the pre-test and re-test was shown. The estimate of the sampling error of this mean difference was 16.435. The "t" value of 11.713 with 13 degrees of freedom indicated significance at the .01 level of confidence, and the null hypothesis was therefore rejected.

The weight-training group had a mean score of 509.6428 pounds on the final test which was a mean difference decrease of 60.3572 pounds from the re-test mean score. The estimate of the sampling

error of this mean difference was 16.353. The "t" value of 3.778 with 13 degrees of freedom indicated significance at the .01 level of confidence, and the null hypothesis was therefore rejected.

Both groups gained significantly in leg strength during the eight weeks of training and the loss of strength by the isometric group during the six weeks following cessation of training was not significant. The weight-training group had a significant loss of strength during the six weeks following the cessation of training.

Forearm Strength

In the pre-test of forearm strength, the isometric group had a mean score of 88.6923 pounds; in the re-test this group had a mean score of 93.9231 pounds. A mean score difference increase of 5.2308 pounds was shown. The estimate of the sampling error of this mean difference was 2.06. The "t" value of 2.538 with 12 degrees of freedom was not significant at the .01 level of confidence, and the null hypothesis was therefore retained.

The isometric group had a mean score of 88.9231 pounds on the final test which was a mean difference decrease of 5.0 pounds from the re-test mean score. The estimate of the sampling error of this mean difference was 1.121. The "t" value of 4.46 with 12 degrees of freedom indicated significance at the .01 level of confidence, and the null hypothesis was therefore rejected.

The weight-training group had a mean score of 84.5714 pounds on the pre-test and a mean score of 96.7142 pounds on the re-test. This was a mean difference increase of 12.1428 pounds. The estimate

of the sampling error of this mean difference was 3.288. The "t" value of 3.606 with 13 degrees of freedom indicated significance at the .01 level of confidence, and the null hypothesis was therefore rejected.

In the final test, this group had a mean score of 95.7142 pounds which was a mean difference decrease of 1.0 from the re-test mean score. The estimate of the sampling error of this mean difference was 1.36. The "t" value of .734 with 13 degrees of freedom was not significant at the .01 level of confidence, and the null hypothesis was therefore retained.

The isometric group did not gain forearm strength significantly during the eight weeks of training but lost forearm strength significantly during the six weeks following cessation of training. The weight-training group gained forearm strength significantly during the eight weeks of training but did not lose forearm strength during the six weeks following the cessation of training.

To determine if there was any significant difference between the two groups in the retention of strength, it was decided to treat the data for possible differences between the two groups. The null hypothesis was assumed with respect to the differences between the two groups on values of mean differences found with the groups between the re-test and final test. The null hypothesis was tested in this case by the use of the "t" technique for uncorrelated data from small samples.[1]

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[1]Ibid., p. 223.

Shoulder Dips

The mean difference decrease between the re-test and the final test was 1.6454 shoulder dips for the isometric group and 2.0357 shoulder dips for the weight-training group. The difference between the mean differences of the two groups was 1.1151 shoulder dips. The estimate of the sampling error for the distribution of the differences between the mean differences was .687. The "t" value resulting from the relationship of the actual difference between the mean differences of the two groups and the estimate of the sampling error for the distribution of the differences between the mean differences was 1.675. With 25 degrees of freedom, this "t" value indicated no significant difference between the two groups and therefore the null hypothesis was retained.

Back Strength

The mean difference decrease between the re-test and the final test was 36.5385 pounds for the isometric group and 26.0715 pounds for the weight-training group. The difference between the mean differences of the two groups was 10.467 pounds. The estimate of the sampling error for the distribution of the differences between the mean differences was 14.248. The "t" value resulting from the relationship of the actual difference between mean differences of the two groups and the estimate of the sampling error for the distribution of the differences between the mean differences was .735. With 25 degrees of freedom this "t" value indicated no significant difference between the two groups and therefore the null hypothesis was retained.

Leg Strength

The mean difference decrease between the re-test and the final test was 20.7693 pounds for the isometric group and 60.3572 pounds for the weight-training group. The difference between the mean differences of the two groups was -49.478 pounds. The estimate of the sampling for the distribution of the differences between mean differences was 30.056. The "t" value resulting from the relationship of the actual difference between the mean differences of the two groups and the estimate of the sampling error for the distribution of the differences between the mean differences was 1.646. With 25 degrees of freedom, this "t" value indicated no significant difference between the two groups and therefore the null hypothesis was retained.

Forearm Strength

The mean difference decrease between the re-test and the final test was 5.0 pounds for the isometric group and 1.0 pounds for the weight-training group. The difference between the mean differences of the two groups was 4.0 pounds. The estimate of the sampling error for the distribution of the differences between the mean differences was 1.763. The "t" value resulting from the relationship of the actual difference between the mean differences of the two groups and the estimate of the sampling error for the distribution of the differences between the mean differences was 2.269. With 25 degrees of freedom this "t" value indicated no significant difference between the two groups and therefore the null hypothesis was retained.

TABLE 1

MEAN SCORES IN TESTS OF SUBJECTS

ISOMETRIC GROUP

	Pre-Test	Re-Test	Final Test
Shoulder Dips	10.6638	16.2692	14.6538
Back Strength	319.2307	410.0000	373.4615
Leg Strength	554.6153	757.6923	736.9230
Forearm Strength	88.6923	93.9231	88.9231

WEIGHT-TRAINING GROUP

	Pre-Test	Re-Test	Final Test
Shoulder Dips	12.7142	21.1428	19.1071
Back Strength	303.5714	350.0000	323.9285
Leg Strength	377.5000	570.0000	509.6428
Forearm Strength	84.5714	96.7142	95.7142

TABLE 2

MEAN DIFFERENCE INCREASE BETWEEN THE PRE-TEST AND RE-TEST

	Isometric Group	Weight-Training Group
Shoulder Dips	5.6154	8.4286
Back Strength	90.7693	46.4286
Leg Strength	203.0770	192.5000
Forearm Strength	5.2308	12.1428

TABLE 3

MEAN DIFFERENCE DECREASE BETWEEN THE RE-TEST AND FINAL TEST

	Isometric Group	Weight-Training Group
Shoulder Dips	1.6454	2.0357
Back Strength	36.5385	26.0715
Leg Strength	20.7693	60.3572
Forearm Strength	5.0000	1.0000

TABLE 4

"t" AND THE SIGNIFICANCE OF DIFFERENCE
BETWEEN THE PRE-TEST AND RE-TEST

Area of Comparison	"t" Value of Isometric Group	"t" Value of Weight-Training Group
Shoulder Dips	16.68 Significant at .01 level	6.866 Significant at .01 level
Back Strength	6.271 Significant at .01 level	3.145 Significant at .01 level
Leg Strength	6.286 Significant at .91 level	11.713 Significant at .01 level
Forearm Strength	2.539 Not Significant at .01 level	3.606 Significant at .01 level

"t" AND THE SIGNIFICANCE OF DIFFERENCE
BETWEEN THE RE-TEST AND FINAL TEST

Area of Comparison	"t" Value of Isometric Group	"t" Value of Weight-Training Group
Shoulder Dips	2.853 Not Significant at .01 level	1.190 Not Significant at .01 level
Back Strength	3.405 Significant at .01 level	2.973 Not Significant at .01 level
Leg Strength	.488 Not Significant at .01 level	3.778 Significant at .01 level
Forearm Strength	4.460 Significant at .01 level	.734 Not Significant at .01 level

TABLE 6

"t" AND THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN GROUPS BETWEEN THE RE-TEST AND FINAL TEST

Area of Comparison	"t" Value and Significance
Shoulder Dips	1.675 Not Significant at .01 level
Back Strength	.735 Not Significant at .01 level
Leg Strength	1.646 Not Significant at .01 level
Forearm Strength	2.269 Not Significant at .01 level

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine the difference, if any, in the retention of strength obtained by taking part in a weight-training program of exercises as opposed to a program of isometric exercises.

The subjects selected for this study were freshman and sophomore male students at the University of North Dakota enrolled in the required physical education program. This selection was a random choice of one weight-training class and one isometric class. Fourteen subjects made up the weight-training group and thirteen subjects made up the isometric group. Both groups participated in their respective exercise programs for a period of eight weeks. At the end of the eight week training period, the subjects participated in unrelated activities consisting of three weeks of slow-pitch softball and three weeks of golf.

Each group was tested relative to strength on four test items consisting of shoulder dips on parallel bars, back strength measured by a dynamometer, leg strength measured by a dynamometer, and forearm strength measured by a cable-tensiometer. These test items were administered at the beginning of the experimental period, after eight weeks of training, and at the end of the six weeks of unrelated activity.

Comparisons were made between the mean differences within each group on each test item as indicated by the pre-test and re-test, and the re-test and final test. The null hypothesis was assumed with respect to the differences within the groups. This hypothesis was tested with the "t" technique for the difference between means derived from correlated scores from small samples. Comparisons were also made between the weight-training group and isometric group by testing the significance of the difference between the mean differences found within the groups. The between group comparison used the "t" technique for uncorrelated data from small samples.

Conclusions

The following conclusions seem warranted on the basis of the data collected in this study.

1. The weight-training group gained significantly at the .01 level of confidence in all test items during the eight week training period.

2. The isometric group gained significantly in all test items at the .01 level of confidence except forearm strength during the eight week training period.

3. The weight-training group had a significant leg strength loss during the six weeks following the cessation of training but had no significant losses in the other three test items.

4. The isometric group had significant losses in back and forearm strength during the six weeks following

the cessation of training but had no significant losses in leg or shoulder strength.

5. Based on the results of this study, it seems apparent that there were some differences in the retention of strength on test items within the groups. However, the treatment of the data with respect to the differences between the two groups indicated no significant difference at the .01 level of confidence with respect to strength retention.

6. From this treatment of the data it was concluded that there is no difference in the retention of strength obtained by taking part in an isometric program of exercises as compared to a weight-training program of exercises.

Recommendations

1. It is recommended that further investigations be made in this area using more subjects, longer training periods, and longer cessation periods.

2. It is recommended that a similar study be conducted to determine if the retention of strength from the accentric method of gaining strength (a forceful elongation of a contracting muscle) is significantly different than the isometric or isotonic methods.

3. It is recommended that a similar investigation be conducted to determine if there are any significant differences in the retention of strength between a control group and groups using isometric, isotonic, and eccentric methods of obtaining strength.

4. It is recommended that a similar study be conducted to determine the effects on strength retention of using more frequent exercise bouts to obtain strength.

5. It is recommended that investigations be made relative to strength retention when the exercise bouts concentrate on endurance training.

6. Because the strength gained by the isometric group in the forearm was not significant and the loss of strength was significant, and because the forearm strength gain for the isotonic group was significant and the strength loss was not significant, it is recommended that studies be conducted to determine whether similar results will be consistently obtained or whether these findings were phenomena particular to this study alone.

INDIVIDUAL SCORING CARD

NAME _____

GROUP _____

	PRE-TEST	RE-TEST	FINAL TEST
SHOULDER DIPS	_____	_____	_____
BACK STRENGTH	_____	_____	_____
LEG STRENGTH	_____	_____	_____
FOREARM STRENGTH	_____	_____	_____

SPECIFIC TEST ITEM SCORES

GROUP-Isometric TEST-Shoulder Dips

Subject	Pre-Test	Re-Test	Final Test
1.	12.0	19.0	15.0
2.	5.0	8.0	10.0
3.	14.0	16.5	16.0
4.	12.0	16.5	15.0
5.	16.0	24.5	20.0
6.	9.0	17.5	18.5
7.	14.0	18.0	16.5
8.	5.0	9.5	8.5
9.	11.0	17.5	14.5
10.	10.0	16.0	15.0
11.	11.0	18.0	17.0
12.	10.5	20.0	15.0
13.	9.0	10.5	9.5
SUM =	138.5	211.5	190.5
MEAN =	10.6538	16.2692	14.6538

SPECIFIC TEST ITEM SCORES

GROUP-Isometric TEST-Back Strength

Subject	Pre-Test	Re-Test	Final Test
1.	360	470	450
2.	280	340	330
3.	280	440	400
4.	380	540	530
5.	290	450	430
6.	420	450	460
7.	280	360	300
8.	260	280	260
9.	290	310	300
10.	350	480	415
11.	280	410	300
12.	290	400	290
13.	390	400	390
SUM =	4140.0	5330.0	4855.0
MEAN =	319.2307	410.0	373.4615

SPECIFIC TEST ITEM SCORES

GROUP-Isometric TEST-Leg Strength

Subject	Pre-Test	Re-Test	Final Test
1.	640	980	950
2.	400	570	520
3.	600	880	770
4.	800	850	880
5.	620	660	800
6.	650	970	850
7.	400	610	570
8.	340	650	570
9.	400	530	540
10.	650	820	700
11.	560	580	650
12.	590	860	850
13.	560	880	980
	SUM = 7210.0	9850.0	9580.0
	MEAN = 554.8153	757.6923	736.923

SPECIFIC TEST ITEM SCORES

GROUP-Isometric TEST-Forearm Strength

Subject	Pre-Test	Re-Test	Final Test
1.	95	107	102
2.	80	72	67
3.	77	93	92
4.	125	120	110
5.	105	112	105
6.	102	100	87
7.	80	80	75
8.	92	83	80
9.	72	75	78
10.	85	95	97
11.	83	92	87
12.	77	87	83
13.	100	105	103
SUM =	1153.0	1221.0	1156.0
MEAN =	88.6923	93.9231	88.9231

SPECIFIC TEST ITEM SCORES

GROUP-Weight-Training TEST-Shoulder Dips

Subject	Pre-Test	Re-Test	Final Test
1.	17.5	30.5	28.5
2.	12.0	23.5	20.0
3.	8.0	17.5	19.0
4.	12.0	18.5	19.0
5.	10.0	13.5	17.0
6.	9.0	19.5	19.0
7.	12.0	11.5	10.5
8.	16.5	23.5	22.0
9.	16.5	23.0	23.0
10.	15.0	24.0	23.0
11.	8.0	11.0	10.0
12.	16.0	20.5	20.0
13.	16.0	23.0	23.0
14.	9.5	13.5	13.5
SUM =	178.0	296.0	287.5
MEAN =	12.7142	21.1428	19.1071

SPECIFIC TEST ITEM SCORES

GROUP-Weight-Training TEST-Back Strength

Subject	Pre-Test	Re-Test	Final Test
1.	300	440	425
2.	290	290	260
3.	310	330	320
4.	380	400	410
5.	250	270	285
6.	320	400	385
7.	240	240	250
8.	320	330	320
9.	335	350	290
10.	250	340	310
11.	250	340	300
12.	295	450	330
13.	380	420	400
14.	330	300	250
SUM =	4250.0	4900.0	4535.0
MEAN =	303.5714	350.0	323.9285

SPECIFIC TEST ITEM SCORES

GROUP-Weight-Training TEST-Leg Strength

Subject	Pre-Test	Re-Test	Final Test
1.	350	460	445
2.	275	390	350
3.	385	560	560
4.	520	630	650
5.	370	590	510
6.	390	610	450
7.	310	520	500
8.	300	430	460
9.	450	740	700
10.	350	580	540
11.	310	440	430
12.	385	600	540
13.	490	670	550
14.	400	560	450
SUM =	5285.0	7980.0	7135.0
MEAN =	377.5	570.0	509.6428

SPECIFIC TEST ITEM SCORES

GROUP-Weight-Training TEST-Forearm Strength

Subject	Pre-Test	Re-Test	Final Test
1.	75	88	82
2.	95	105	103
3.	72	93	92
4.	104	108	100
5.	60	70	78
6.	77	80	87
7.	92	90	100
8.	75	97	94
9.	80	117	120
10.	82	100	95
11.	72	84	80
12.	100	105	103
13.	100	107	106
14.	100	110	105
SUM =	1184.0	1354.0	1340.0
MEAN =	84.5714	96.7142	95.7142

CUMULATIVE TEST ITEM SCORES

GROUP-Isometric TEST-Pre-Test

Subject	Shoulder Dips	Back Strength	Leg Strength	Forearm Strength
1.	12.0	360	640	95
2.	5.0	290	400	60
3.	14.0	280	600	77
4.	12.0	360	800	125
5.	16.0	290	620	105
6.	9.0	420	650	102
7.	14.0	280	400	80
8.	5.0	260	340	92
9.	11.0	290	400	72
10.	10.0	350	650	85
11.	11.0	280	580	83
12.	10.5	290	590	77
13.	9.5	290	580	100
SUM	= 138.5	4150.0	7210.0	1153.0
MEAN	= 10.6538	319.2307	554.6153	88.6923

GROUP-Weight-Training TEST-Pre-Test

Subject	Shoulder Dips	Back Strength	Leg Strength	Forearm Strength
1.	17.5	300	350	75
2.	12.0	290	275	95
3.	8.0	310	385	72
4.	12.0	380	520	104
5.	10.0	250	370	80
6.	9.0	320	390	77
7.	12.0	240	310	92
8.	16.5	320	300	75
9.	16.5	325	450	80
10.	15.0	250	350	82
11.	8.0	250	310	72
12.	16.0	295	385	100
13.	16.0	380	490	100
14.	9.5	330	400	100
SUM	= 178.0	4250.0	5285.0	1184.0
MEAN	= 12.7142	303.5714	377.5	84.5714

CUMULATIVE TEST ITEM SCORES

GROUP-Isometric TEST-Re-Test

Subject	Shoulder Dips	Back Strength	Leg Strength	Forearm Strength
1.	19.0	470	990	107
2.	8.0	340	570	72
3.	16.5	440	880	93
4.	16.5	540	850	120
5.	24.5	450	660	112
6.	17.5	450	970	100
7.	18.0	360	610	80
8.	9.5	280	650	83
9.	17.5	310	530	75
10.	16.0	480	820	95
11.	18.0	410	580	92
12.	20.0	400	860	87
13.	10.5	400	880	105
SUM	= 211.5	5330.0	9850.0	1221.0
MEAN	= 16.2692	410.0	757.6923	93.9231

GROUP-Weight-Training TEST-Re-Test

Subject	Shoulder Dips	Back Strength	Leg Strength	Forearm Strength
1.	30.5	440	480	88
2.	23.5	290	390	105
3.	17.5	330	560	93
4.	18.5	400	830	108
5.	13.5	270	590	70
6.	19.5	400	610	80
7.	11.5	240	520	90
8.	23.5	330	430	97
9.	23.0	350	740	117
10.	24.0	340	580	100
11.	11.0	340	440	84
12.	20.5	450	600	107
13.	23.0	420	670	105
14.	13.5	300	560	110
SUM	= 296.0	4900.0	7980.0	1354.0
MEAN	= 21.1428	350.0	570.0	96.7142

CUMULATIVE TEST ITEM SCORES

GROUP-Isometric TEST-Final

Subject	Shoulder Dips	Back Strength	Leg Strength	Forearm Strength
1.	15.0	450	950	102
2.	10.0	330	520	67
3.	16.0	400	770	92
4.	15.0	530	880	110
5.	20.0	430	800	105
6.	18.5	460	850	87
7.	16.5	300	570	75
8.	6.5	260	520	80
9.	14.5	300	540	78
10.	15.0	415	700	87
11.	17.0	300	650	97
12.	15.0	290	850	83
13.	9.5	390	980	108
SUM	= 190.5	4855.0	9580.0	1156.0
MEAN	= 14.6538	373.4615	736.923	88.9231

GROUP-Weight-Training TEST-Final

Subject	Shoulder Dips	Back Strength	Leg Strength	Forearm Strength
1.	26.5	425	445	82
2.	20.0	250	350	103
3.	19.0	320	560	92
4.	19.0	410	650	100
5.	17.0	285	510	73
6.	19.0	385	450	87
7.	10.5	250	500	100
8.	22.0	320	460	94
9.	28.0	290	700	120
10.	23.0	310	540	95
11.	10.0	300	430	80
12.	20.0	330	540	106
13.	23.0	400	550	103
14.	13.5	250	450	105
SUM	= 267.5	4535.0	7135.0	1340.0
MEAN	= 19.1071	323.9285	509.6428	95.7142

PRE-TEST AND RE-TEST OF ISOMETRIC GROUP IN SHOULDER DIPS

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	12.0	19.0	7.0	49.0
2.	5.0	8.0	3.0	9.0
3.	14.0	16.5	2.5	6.25
4.	12.0	16.5	4.5	24.75
5.	16.0	24.5	8.5	72.25
6.	9.0	17.5	8.5	72.25
7.	14.0	18.0	4.0	16.0
8.	5.0	9.5	4.5	24.75
9.	11.0	17.5	6.5	42.25
10.	10.0	16.0	6.0	36.0
11.	11.0	18.0	7.0	49.0
12.	10.5	20.0	9.5	89.25
13.	9.0	10.5	1.5	2.25
	138.5	211.5	75.0	414.0

Mean Score of Pre-Test	10.6538
Mean Score of Re-Test	16.2692
Sum of the Differences	75.0
Sum of the Differences Squared	414.0

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Shoulder Dips GROUP Isometric

N 13

D 75

D^2 414

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\bar{D}} = \frac{D}{\sqrt{N}} =$

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{N-1} \qquad \frac{\sqrt{414 - \frac{(75)^2}{13}}}{12}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = .346

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{75}{13} = 5.77$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{5.77}{.346} = 16.68$

df = N-1 = 12

"t" at the .01 level = 3.06

Significant at .01 level

PRE-TEST AND RE-TEST OF ISOMETRIC GROUP IN BACK STRENGTH

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	360	470	110	12100
2.	280	340	60	3600
3.	280	440	160	25600
4.	380	540	160	25600
5.	290	450	160	25600
6.	420	450	30	900
7.	280	360	80	6400
8.	260	280	20	400
9.	290	310	20	400
10.	350	480	130	16900
11.	280	410	130	16900
12.	290	400	110	12100
13.	390	400	10	100
	4150.0	5330.0	1180	146600

Mean Score of Pre-Test	319.2307
Mean Score of Re-Test	410.0
Sum of Difference	1180.0
Sum of the Difference Squared	146600.0

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Back Strength GROUP Isometric

N 13

D 1180

D^2 146,600

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{\sqrt{N-1}} \qquad \frac{\sqrt{146{,}600 - \frac{(1180)^2}{13}}}{\sqrt{12}}$$

$S_{\bar{D}}$ = 15.909

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{1180}{13} = 90.77$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{90.77}{15.909} = 6.271$

df = N-1 = 12

"t" at the .01 level = 3.06

Significant at .01 level

PRE-TEST AND RE-TEST OF ISOMETRIC GROUP IN LEG STRENGTH

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	640	990	350	122500
2.	400	570	170	29900
3.	600	880	280	78400
4.	800	850	50	2500
5.	620	660	40	1600
6.	650	970	320	102400
7.	400	610	210	44100
8.	340	650	310	96100
9.	400	530	130	16900
10.	650	820	170	28900
11	560	580	20	400
12.	590	860	270	72900
13.	560	880	320	102400
	7210	9850	2640	699000

Mean Score of Pre-Test	554.6153
Mean Score of Re-Test	757.6923
Sum of the Difference	2640
Sum of the Difference Squared	699000

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Leg Strength GROUP Isometric

N 13

D 2640

D^2 699,000

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\bar{D}} = \sqrt{\frac{D}{N}}$ =

$$\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{699{,}000 - \frac{(2640)^2}{13}}{12}}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = 32.308

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{2640}{13} = 203.077$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{203.077}{32.308} = 6.2866$

df = N-1 = 12

"t" at the .01 level = 3.06

Significant at .01 level

PRE-TEST AND RE-TEST OF ISOMETRIC GROUP IN FOREARM STRENGTH

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	95	107	12	144
2.	60	72	12	144
3.	77	93	16	256
4.	125	120	-5	25
5.	105	112	7	49
6.	102	100	-2	4
7.	80	80	0	0
8.	92	83	-9	81
9.	72	75	3	9
10.	85	95	10	100
11.	83	92	9	81
12.	77	87	10	100
13.	100	105	5	25
	1153	1221	68	1018

Mean Score of Pre-Test	88.6923
Mean Score of Re-Test	93.9231
Sum of the Difference	68
Sum of the Difference Squared	1018

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Forearm Strength GROUP Isometric

N 13

D 68

D^2 1018

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\bar{D}} = \frac{D}{\sqrt{N}} =$

$$\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{1018 - \frac{(68)^2}{13}}{12}}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = 2.06

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = 5.231

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{5.231}{2.06} =$ 2.539

df = N-1 = 12

"t" at the .01 level = 3.06

Not Significant at .01 level.

PRE-TEST AND RE-TEST OF WEIGHT TRAINING GROUP IN SHOULDER DIPS

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	17.5	30.5	13.0	169.00
2.	12.0	23.5	11.5	132.25
3.	8.0	17.5	9.5	90.25
4.	12.0	18.5	6.5	42.25
5.	10.0	13.5	3.5	12.25
6.	9.0	19.5	10.5	110.25
7.	12.0	11.5	- .5	.25
8.	16.5	23.5	7.0	49.00
9.	16.5	23.0	6.5	42.25
10.	15.0	24.0	9.0	81.00
11.	8.0	11.0	3.0	9.00
12.	16.0	20.5	4.5	20.25
13.	16.0	23.0	7.0	49.00
14.	9.5	13.5	4.0	16.00
	178.0	296.0	95.0	823.00

Mean Score of Pre-Test	12.7142
Mean Score of Re-Test	21.1428
Sum of the Difference	95
Sum of the Difference Squared	823

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Shoulder Dips GROUP Weight-Training

N 14

D 95

D^2 823

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{823 - \frac{(95)^2}{14}}{13}}$$

$$\sqrt{N} \qquad \sqrt{14}$$

$S_{\bar{D}}$ = .989

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{95}{14} = 6.79$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{6.79}{.989} = 6.866$

df = N-1 = 13

"t" at the .01 level = 3.01

Significant at .01 level

PRE-TEST AND RE-TEST OF WEIGHT TRAINING GROUP IN BACK STRENGTH

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	300	440	140	19600
2.	290	290	0	0
3.	310	330	20	400
4.	380	400	20	400
5.	250	270	20	400
6.	320	400	80	6400
7.	240	240	0	0
8.	320	330	10	100
9.	335	350	15	225
10.	250	340	90	8100
11.	250	340	90	8100
12.	295	450	155	24025
13.	380	420	40	1600
14.	330	300	-30	900
	4250	4900	650	70250

Mean Score of Pre-Test	303.5714
Mean Score of Re-Test	323.9285
Sum of the Difference	650
Sum of the Difference Squared	70250

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Back Strength GROUP Weight-Training

N 14

D 650

D^2 70,250

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{70{,}250 - \frac{(650)^2}{14}}{13}}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{14}}$$

$S_{\bar{D}}$ = 14.764

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{650}{14} =$ 46.429

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{46.429}{14.764} =$ 3.145

df = N-1 = 13

"t" at the .01 level = 3.01

Significant at .01 level

PRE-TEST AND RE-TEST OF WEIGHT TRAINING GROUP IN LEG STRENGTH

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	350	460	110	12100
2.	275	390	115	13225
3.	385	560	175	30625
4.	520	830	310	96100
5.	370	590	220	48400
6.	390	610	220	48400
7.	310	520	210	44100
8.	300	430	130	16900
9.	450	740	290	84100
10.	350	580	230	52900
11.	310	440	130	16900
12.	385	600	215	46225
13.	490	670	180	32400
14.	400	560	160	25600
	5285	7980	2695	567975

Mean Score of Pre-Test 377.5

Mean Score of Re-Test 570.0

Sum of the Difference 2695

Sum of the Difference Squared 567975

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Leg Strength GROUP Weight Training

N 14

D 2695

D^2 567,975

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{N-1} \qquad \frac{\sqrt{567{,}975 - \frac{(2695)^2}{14}}}{13}$$

$$\sqrt{N} \qquad \sqrt{14}$$

$S_{\bar{D}}$ = 16.435

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{2695}{14} = 192.5$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{192.5}{16.435} = 11.713$

df = N-1 = 13

"t" at the .01 level = 3.01

Significant at .01 level

PRE-TEST AND RE-TEST OF WEIGHT TRAINING GROUP IN FOREARM STRENGTH

Subject	Pre-Test	Re-Test	Sum of Difference	Difference Squared
1.	75	88	13	169
2.	95	105	10	100
3.	72	93	21	441
4.	104	108	4	16
5.	60	70	10	100
6.	77	80	3	9
7.	92	90	-2	4
8.	75	97	18	324
9.	80	117	37	1369
10.	82	100	18	324
11.	72	84	12	144
12.	100	107	7	49
13.	100	105	5	25
14.	100	110	10	100
	1184	1354	166	3174

Mean Score of Pre-Test 84.5714

Mean Score of Re-Test 96.7142

Sum of the Difference 166

Sum of the Difference Squared 3174

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Pre-Test and Re-Test TEST Forearm Strength GROUP Weight Training

N 14

D 166

D^2 3174

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \Big/ \sqrt{N} \qquad \sqrt{\frac{3174 - \frac{(166)^2}{14}}{13}} \Big/ \sqrt{14}$$

$S_{\bar{D}}$ = 3.288

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{166}{14} =$ 11.857

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{11.857}{3.288} =$ 3.606

df = N-1 = 13

"t" at the .01 level = 3.01

Significant at .01 level

RE-TEST AND FINAL TEST OF ISOMETRIC GROUP IN SHOULDER DIPS

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	19.0	15.0	-4.0	16.00
2.	8.0	10.0	2.0	4.00
3.	16.5	16.0	-.5	.25
4.	16.5	15.0	-1.5	2.25
5.	24.5	20.0	-4.5	20.25
6.	17.5	18.5	1.0	1.00
7.	18.0	16.5	-1.5	2.25
8.	9.5	8.5	-1.0	1.00
9.	17.5	14.5	-3.0	9.00
10.	16.0	15.0	-1.0	1.00
11.	18.0	17.0	-1.0	1.00
12.	20.0	15.0	-5.0	25.00
13.	10.5	9.5	-1.0	1.00
	211.5	190.5	-21.0	84.00

Mean Score of Re-Test	16.2692
Mean Score of Retention Test	14.6538
Sum of the Difference	-21.0
Sum of the Difference Squared	84.00

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Shoulder Dips GROUP Isometric

N 13

D -21

D^2 84

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\bar{D}} = \frac{D}{\sqrt{N}} =$

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{\sqrt{N-1}} \qquad \frac{\sqrt{84 - \frac{(-21)^2}{13}}}{\sqrt{12}}$$

$S_{\bar{D}}$ = .566

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{-21}{13} = 1.615$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{1.615}{.566} = 2.853$

df = N-1 = 12

"t" at the .01 level = 3.06
Not
Significant at .01 level

RE-TEST AND FINAL TEST OF ISOMETRIC GROUP IN BACK STRENGTH

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	470	450	-20	400
2.	340	330	-10	100
3.	440	400	-40	1600
4.	540	530	-10	100
5.	450	430	-20	400
6.	450	460	10	100
7.	360	300	-60	3600
8.	280	260	-20	400
9.	310	300	-10	100
10.	480	415	-65	4225
11.	410	300	-110	12100
12.	400	290	110	12100
13.	400	390	-10	100
	5330	4855	-475	35325

Mean Score of Re-Test 410.0

Mean Score of Retention Test 373.4615

Sum of the Difference -475

Sum of the Difference Squared 35325

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Back Strength GROUP Isometric

N 13

D -475

D^2 35,325

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\bar{D}} = \dfrac{D}{\sqrt{N}} =$

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{N-1} \qquad \frac{\sqrt{35{,}325 - \frac{(-475)^2}{13}}}{12}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = 10.732

$\bar{D}$ (Mean Difference) = $\dfrac{D}{N} = \dfrac{-475}{13} = 36.538$

"t" = $\dfrac{\bar{D}}{S_{\bar{D}}} = \dfrac{36.538}{10.732} = 3.405$

df = N-1 = 12

"t" at the .01 level = 3.06

Significant at .01 level

RE-TEST AND FINAL TEST OF ISOMETRIC GROUP IN LEG STRENGTH

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	990	950	-40	1600
2.	570	520	-50	2500
3.	880	770	-110	12100
4.	850	880	30	900
5.	660	800	140	19600
6.	970	850	-120	14400
7.	610	570	-40	1600
8.	650	520	-130	16900
9.	530	540	10	100
10.	820	700	-120	14400
11.	590	650	70	4900
12.	860	850	-10	100
13.	880	980	110	12100
	9850	9580	-160	101200

Mean Score of Re-Test	757.6923
Mean Score of Retention Test	736.923
Sum of the Difference	-160
Sum of the Difference Squared	101200

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Leg Strength GROUP Isometric

N 13

D -160

D^2 101,200

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{101{,}200 - \frac{(-160)^2}{13}}{12}}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = 25.218

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{-160}{13} = 12.308$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{12.508}{25.218} = .488$

df = N-1 = 12

"t" at the .01 level = 3.06

Not significant at .01 level

RE-TEST AND FINAL TEST OF ISOMETRIC GROUP IN FOREARM STRENGTH

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	107	102	-5	25
2.	72	67	-5	25
3.	93	92	-1	1
4.	120	110	-10	100
5.	112	105	-7	49
6.	100	87	-13	169
7.	80	75	-5	25
8.	83	80	-3	9
9.	75	78	3	9
10.	95	87	-8	64
11.	92	97	-5	25
12.	87	83	-4	16
13.	105	103	-2	4
	1221	1156	-65	521

Mean Score of Re-Test 93.9231

Mean Score of Retention Test 88.9231

Sum of the Difference -65

Sum of the Difference Squared 521

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Forearm Strength GROUP Isometric

N 13

D -65

D^2 521

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{N-1} \qquad \frac{\sqrt{521 - \frac{(-65)^2}{13}}}{12}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = 1.121

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{-65}{13} = 5.00$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{5.00}{1.121} = 4.460$

df = N-1 = 12

"t" at the .01 level = 3.06

Significant at .01 level

RE-TEST AND FINAL TEST OF WEIGHT TRAINING GROUP IN SHOULDER DIPS

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	30.5	28.5	-2	4.00
2.	23.5	20.0	-3.5	12.25
3.	17.5	19.0	1.5	2.25
4.	18.5	19.0	.5	.25
5.	13.5	17.0	2.5	6.25
6.	19.5	19.0	-.5	.25
7.	11.5	10.5	-1.0	1.00
8.	23.5	22.0	-1.5	2.25
9.	23.0	23.0	0.0	0.00
10.	24.0	23.0	-1.0	1.00
11.	11.0	10.0	-1.0	1.00
12.	20.5	20.0	-.5	.25
13.	23.0	23.0	0.0	0.00
14.	13.5	13.5	0.0	0.00
	296.0	267.5	-6.5	30.75

Mean Score of Re-Test	21.1428
Mean Score of Retention Test	19.1071
Sum of the Difference	-6.5
Sum of the Difference Squared	30.75

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Shoulder Dips GROUP Weight Training

N 14

D -6.5

D^2 30.75

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\bar{D}} = \frac{D}{\sqrt{N}} =$

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{N-1} \Big/ \sqrt{N} \qquad \frac{\sqrt{30.75 - \frac{(-6.5)^2}{14}}}{13} \Big/ \sqrt{14}$$

$S_{\bar{D}}$ = .390

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{-6.5}{14} =$ .464

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{.464}{.390} =$ 1.19

df = N-1 = 13

"t" at the .01 level = 3.01

Not significant at the .01 level

RE-TEST AND FINAL TEST OF WEIGHT TRAINING GROUP IN BACK STRENGTH

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	440	425	-15	225
2.	290	260	-30	900
3.	330	320	-10	100
4.	400	410	10	100
5.	270	285	15	225
6.	400	385	-15	225
7.	240	250	10	100
8.	330	320	-10	100
9.	350	290	-60	3600
10.	340	310	-30	900
11.	340	300	-40	1600
12.	450	330	-120	14400
13.	420	400	-20	400
14.	300	250	-50	2500
	4900	4535	-365	25375

Mean Score of Re-Test	350.0
Mean Score of Retention Test	323.9285
Sum of the Difference	-365
Sum of the Difference Squared	25375

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Back Strength GROUP Weight Training

N 14

D -365

D^2 25,375

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\bar{D}} = \frac{D}{\sqrt{N}} =$

$$\frac{\sqrt{D^2 - \frac{(D)^2}{N}}}{N-1} \qquad \frac{\sqrt{25{,}375 - \frac{(365)^2}{14}}}{13}$$

$$\sqrt{N} \qquad \sqrt{14}$$

$S_{\bar{D}}$ = 9.334

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{-365}{14} = 26.071$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{26.071}{9.334} = 2.973$

df = N-1 = 13

"t" at the .01 level = 3.01

Not significant at the .01 level

RE-TEST AND FINAL TEST OF WEIGHT TRAINING IN LEG STRENGTH

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	460	445	-15	225
2.	390	350	-40	1600
3.	560	560	0	0
4.	830	650	-180	32400
5.	590	510	-80	6400
6.	610	450	-160	25600
7.	520	500	-40	1600
8.	430	460	30	900
9.	740	700	-40	1600
10.	580	540	-40	1600
11.	440	430	-10	100
12.	600	540	-60	3600
13.	670	550	-120	14400
14.	560	450	-110	12100
	7980	7135	-855	102125

Mean Score of Re-Test	570.0
Mean Score of Retention Test	509.6428
Sum of the Difference	-855
Sum of the Difference Squared	102125

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Leg Strength GROUP Weight Training

N 14

D -865

D^2 102,125

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$ =

$$\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{102{,}125 - \frac{(-865)^2}{14}}{13}}$$

$$\sqrt{N} \qquad \sqrt{14}$$

$S_{\bar{D}}$ = 16.353

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{-865}{14} = 61.786$

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{61.786}{16.353} = 3.778$

df = N-1 = 13

"t" at the .01 level = 3.01

Significant at the .01 level

RE-TEST AND FINAL TEST OF WEIGHT TRAINING GROUP IN FOREARM STRENGTH

Subject	Re-Test	Retention Test	Sum of Difference	Difference Squared
1.	88	82	-6	36
2.	105	103	-2	4
3.	93	92	-1	1
4.	108	100	-8	16
5.	70	73	3	9
6.	80	87	7	49
7.	90	100	10	100
8.	97	94	-3	9
9.	117	120	3	9
10.	100	95	-5	25
11.	84	80	-4	16
12.	107	106	-1	1
13.	105	103	-2	4
14.	110	105	-5	25
	1354	1340	-14	352

Mean Score of Re-Test	96.7142
Mean Score of Retention Test	95.7142
Sum of the Differences	-14
Sum of the Difference Squared	352

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

BETWEEN Re-Test and Final TEST Forearm Strength GROUP Weight Training

N 14

D -14

D^2 350

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $S_{\frac{D}{\sqrt{N}}}$

$$S_{\bar{D}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \Big/ \sqrt{N} \qquad \sqrt{\frac{350 - \frac{(-14)^2}{14}}{13}} \Big/ \sqrt{14}$$

$S_{\bar{D}}$ = 1.363

$\bar{D}$ (Mean Difference) = $\frac{D}{N} = \frac{-14}{14}$ = 1.000

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{1.000}{1.363}$ = .734

df = N-1 = 13

"t" at the .01 level = 3.01

Not significant at .01 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM UNCORRELATED SCORES FROM SMALL SAMPLES

TEST Shoulder Dips

Isometric Group $\bar{D}$ = 1.615 Weight-Training Group $\bar{D}$ = .464

Isometric Group $S_{\bar{D}}$ = .566 Weight-Training Group $S_{\bar{D}}$ = .390

S_{D_M} (the estimate of the sampling error for the distribution of differences between the mean differences) =

$$\sqrt{\left(S_{\bar{D}_1}\right)^2 + \left(S_{\bar{D}_2}\right)^2} \qquad \sqrt{(.566)^2 + (.39)^2}$$

S_{D_M} = .687

$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = 1.615 - .464 = 1.151$

$$\text{"t"} = \frac{D_{\bar{D}}}{S_{D_M}} = \frac{1.151}{.687} = 1.675$$

$df = (N_1 - 1) + (N_2 - 1) = 25$

"t" at .01 level = 2.79

Not significant at .01 level.

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM UNCORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength

Isometric Group $\bar{D}$ = 36.538 Weight-Training Group $\bar{D}$ = 26.071

Isometric Group $S_{\bar{D}}$ = 10.732 Weight-Training Group $S_{\bar{D}}$ = 9.334

S_{D_M} (the estimate of the sampling error for the distribution of differences between the mean differences).=

$$\sqrt{\left(S_{\bar{D}_1}\right)^2 + \left(S_{\bar{D}_2}\right)^2} \qquad \sqrt{(10.732)^2 + (9.334)^2}$$

S_{D_M} = 14.248

$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = 36.538 - 26.071 = 10.467$

$$\text{"t"} = \frac{D_{\bar{D}}}{S_{D_M}} = \frac{10.467}{14.248} = .735$$

$df = (N_1 - 1) + (N_2 - 1) = 25$

"t" at .01 level = 2.79

Not significant at .01 level.

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM UNCORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength

Isometric Group $\bar{D} = 12.308$ Weight-Training Group $\bar{D} = 61.786$

Isometric Group $S_{\bar{D}} = 25.218$ Weight-Training Group $S_{\bar{D}} = 16.353$

S_{D_M} (the estimate of the sampling error for the distribution of differences between the mean differences) =

$$\sqrt{\left(S_{\bar{D}_1}\right)^2 + \left(S_{\bar{D}_2}\right)^2} \qquad \sqrt{(25.218) + (16.353)}$$

$$\sqrt{635.948 + 267.421} \qquad \sqrt{903.389}$$

$S_{D_M} = 30.056$

$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = 12.308 - 61.786 = -49.478$

$$\text{"t"} = \frac{D_{\bar{D}}}{S_{D_M}} = \frac{-49.478}{30.056} = 1.646$$

$df = (N_1 - 1) + (N_2 - 1) = 25$

"t" at .01 level = 2.79

Not significant at .01 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM UNCORRELATED SCORES FROM SMALL SAMPLES

TEST Forearm

Isometric Group $\bar{D} = 5.00$ Weight-Training Group $\bar{D} = 1.00$

Isometric Group $S_{\bar{D}} = 1.121$ Weight-Training Group $S_{\bar{D}} = 1.36$

S_{D_M} (the estimate of the sampling error for the distribution of differences between the mean differences) =

$$\sqrt{\left(S_{\bar{D}_1}\right)^2 + \left(S_{\bar{D}_2}\right)^2} \qquad \sqrt{(1.121)^2 + (1.36)^2}$$

$$\sqrt{1.257 + 1.85} \qquad \sqrt{3.107}$$

$S_{D_M} = \underline{1.763}$

$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = 5.00 - 1.00 = 4.00$

$$\text{"t"} = \frac{D_{\bar{D}}}{S_{D_M}} = \frac{4.00}{1.763} = \underline{2.269}$$

$df = (N_1 - 1) + (N_2 - 1) = 25$

"t" at .01 level = 2.79

Not significant at .01 level.

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