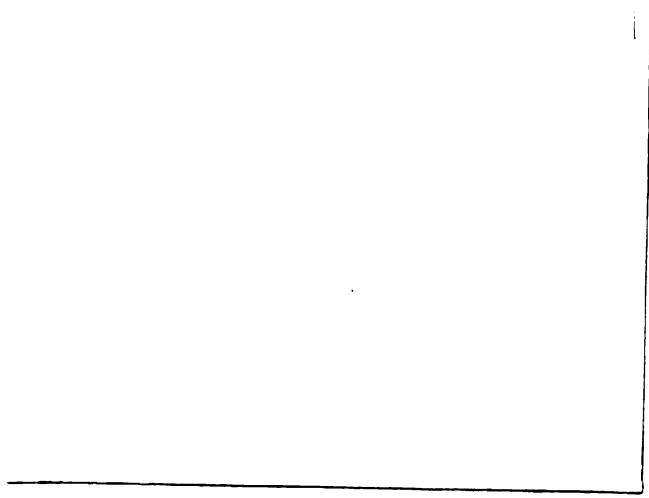




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THE EFFECT OF QUADRICEPS DEVELOPMENT
ON SPRINT RUNNING TIME

Thesis for the Degree of M. A.
MICHIGAN STATE UNIVERSITY
Richard Charles Ouellette
1955



**THE EFFECT OF QUADRICEPS DEVELOPMENT
ON SPRINT RUNNING TIME**

**by
RICHARD CHARLES OUELLETTE**

A THESIS

**Submitted to the College of Education of Michigan State
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ABSTRACT

Title of study. The Effect of Quadriciceps Development on Sprint Running Time.

Statement of problem. To evaluate the influence of progressive resistance exercise on quadriciceps development and sprint running time.

Methodology. Two groups of four subjects each matched in seventy-five yard sprint times were tested in this study. The experimental group consisted of two freshmen track candidates and two members of a track and field class. The experimental group participated in a progressive resistance exercise program. This program consisted of meeting four days a week and performing a knee extension exercise for both right and left legs. At the end of each week a 1 R.M. was determined and recorded.

The control group consisted of one freshmen track candidate and three members of a track and field class who did not participate in progressive resistance exercise. All subjects participated in daily track training and were tested Wednesday and Friday of each week for seven weeks. A two week layoff was brought about because of a between term school vacation and took place between week four and week five.

The testing program consisted of measuring each Wednesday, thigh girth development and tension strength. Friday was set aside for testing seventy-five yard dash times and also determining and recording of one R.M. for the experimental group only. The data was presented graphically and tested statistically by the analysis of variance. When "F" values were significant, small sample "t" tests were utilized to further analyze the data.

Conclusions. The following conclusions are drawn from the basis of the data presented in the study. Any interpretation of these conclusions should be in light of the limitations of the study.

1. Progressive resistance exercise even above the weight loads used in knee exercises had no deleterious effect on sprint running times in either the twenty or seventy-five yard dashes. The trends, in fact, were toward faster times but insignificantly so.

2. No significant differences between groups were found in knee extension strength, as measured by the cable tensiometer.

3. There was a significant increase ($F = 12.1$ and 32.5 at the 1% level) in one R.M. values, from initial to final test, in the experimental group. On the basis of the present study no conclusions can be drawn as to whether this significant increase was due to running or weight training.

ACKNOWLEDGMENTS

The writer wishes to express his grateful acknowledgment to his advisor, Dr. W. D. Van Huss, for his professional guidance, criticisms, and valuable suggestions rendered in this study.

To Dr. H. Montoye for help and advice given in setting up the timing apparatus, acknowledgment also.

Thanks are extended to the subjects who cooperated in this study to the fullest extent.

The author is deeply indebted to his wife, Marilyn, for her valuable assistance in the final preparation of the study.

R. C. O.

DEDICATION

This thesis is respectfully dedicated to my wife,
Marilyn, and to my two daughters, Michele and Marcy.

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CHAPTER I

INTRODUCTION

Knee injuries have long been a threat to athletes. The knee is one of the weakest joints in the body for the pressure put on it and for this reason, many athletes are plagued with knee injuries. Progressive resistance exercise has been one of the more successful clinical approaches to stabilize weakened knees.

Statement of the problem. To evaluate the influence of progressive resistance exercise on quadriceps development and sprint running times.

Need for the study. The effect of progressive resistance exercise on sprint running time has not been established. The question of how much progressive resistance exercise can be given an individual without slowing him down has been a constant problem to the clinical people, coaches, trainers, and the athletes.

DeLorme¹ has pointed out that quadriceps muscles to become powerful enough to maintain the stability of the knee without help of the ligament, must have greater than normal

¹ T. L. DeLorme, "Restoration of Muscle Power by Heavy Resistance Exercise," The Journal of Bone and Joint Surgery, 27: October, 1945, p. 656.

power built in the involved extremity. Therefore, extremely heavy resistance must be used in cases dependent on muscular support of the knee. It is hoped this study, in a small way, will contribute insight to the amount of weight which can be safely used with athletes dependent on running speed.

Limitations of the study. 1. Size of samples. This study was performed with four experimental and four control subjects matched on seventy-five yard running times.

2. Psychological factor. It is difficult to determine whether the subjects are performing maximum lifts or running maximum speed. It is felt, however, errors of this type are at a minimum.

3. One R.M. measure. The one R.M. has its limitations as a means of a strength measurement, principally due to the difficulty in determining exactly when the knee is straight.

4. Control group. A maximum contraction was performed once per week on the tensiometer which has some bearing on increased strength, therefore, adding some bias to the data.

Definitions. The following are defined briefly for use in this study.

Progressive Resistance Exercise - For use in this study, the term progressive resistance exercise refers to load-resisting knee extension exercise. A boot attached to a short bar on which weights are placed, is strapped to the foot and used to exercise the quadriceps muscles.

Load-Resisting Exercises - "This term (load-resisting exercise) refers to those in which the exercise load resists the muscle."²

Ten R.M. - The maximum weight which can be lifted correctly for ten repetitions.

One R.M. - The maximum weight which can be lifted to complete knee extension once.

² T. L. DeLorme and A. L. Watkins, Progressive Resistance Exercise, (New York: Appleton-Century-Crofts, Inc., 1951,) p. 23.

CHAPTER II

RELATED LITERATURE

Nowhere in the human body is the functional integrity of a joint so dependent upon muscle support as it is in the knee. It is true that with a weak quadriceps muscle the individual may be denied very few ordinary daily activities.¹

Introduction to progressive resistance exercise.

DeLorme and Watkins² pointed out that progressive resistance exercise principles and technics as they are now employed therapeutically had their inception in World War II. Due to the urgent need for hospital beds and speedier rehabilitation of the wounded, this type of exercise was developed in Gardiner General Hospital, Chicago, Illinois, in the spring of 1944.

DeLorme, West, and Shiber³ studied the effect of progressive resistance exercise on the knee following femoral fractures of soldiers at Gardiner General Hospital. It was

¹ T. L. DeLorme and A. L. Watkins, Progressive Resistance Exercise, (New York: Appleton-Century-Crofts, Inc., 1951), p. 125.

² Ibid., pp. 1-5.

³ T. L. DeLorme, F. E. West, and W. J. Shiber, "Influence of Progressive Resistance Exercise on Knee Function Following Femoral Fractures," The Journal of Bone and Joint Surgery, 32-A: October, 1950, p. 910.

determined that progressive resistance exercise had aided in faster recovery and more rapid restoration of muscle power.

The scope of progressive resistance exercise has steadily widened since its inception with rehabilitation of veterans of World War II.⁴

The age limits of progressive resistance exercise applications have been extended to include, not only the army age group, but the very young and the aged.⁵

The old term of heavy resistance exercise led to much false interpretation as found by DeLorme and Watkins.⁶ The false interpretation that only great poundage was used and that a muscle initially must have nearly normal power, led to the change in name to progressive resistance exercise.

Purpose and need for progressive resistance exercise.

Progressive resistance exercise is used, primarily, for increasing strength. This exercise is based on the sound physiological principle that in order to rapidly improve muscular strength, one must contract against a resistance which will

⁴ T. L. DeLorme, "Recent Developments in Progressive Resistance Exercise," American Academy of Orthopedic Surgeons Instructional Course Lectures, (Chapter VIII, Progressive Resistance Exercise, Ann Arbor, Michigan: J. W. Edwards, 1950), p. 225.

⁵ Ibid.

⁶ T. L. DeLorme and A. L. Watkins, "Technics of Progressive Resistance Exercise," Archives of Physical Medicine, 29: May, 1948, p. 263.

elicit a near maximal voluntary effort. The resistance must be progressively increased.⁷

DeLorme⁸ found exercise to be essential in restoring function to muscles, which were weakened and atrophied as a result of injury and disease.

DeLorme states:

Most injuries of the thigh and knee result in atrophy of quadriceps of varying degree. When the local injury has healed, redevelopment of quadriceps power is the most important factor in restoring normal function of the extremity.⁹

Gallagher, Andover, and DeLorme¹⁰ note that the tendency for knee injuries to recur is known and that it is all important to combat the atrophy and hypotonia of the extensor muscles of the thigh. It is further stated:

Progressive resistance exercise can restore the power lost, and can produce a much greater strength in the supporting muscles than they possessed prior to the incited injury.¹¹

⁷ A. L. Watkins, "Practical Applications of Progressive Resistance Exercise," Journal of American Medical Association, 148: February, 1952, p. 443.

⁸ T. L. DeLorme, "Restoration of Muscle Power by Heavy Resistance Exercise," The Journal of Bone and Joint Surgery, 27: October, 1945, p. 645.

⁹ Ibid.

¹⁰ J. R. Gallagher, Andover, and T. L. DeLorme, "The Use of the Techniques of Progressive Resistance Exercise in Adolescents," The Journal of Bone and Joint Surgery, 31: October, 1949, p. 847.

¹¹ Ibid.

Robertson and Hawk¹² point out the knee joint is not a simple hinge and that the quadriceps are the most active stabilizers of the joint.

There seems to be ample evidence in the literature, and in our own experience, to prove conclusively that the quadriceps muscle group forms the first line of defense against knee injury.¹³

Exercise effects on muscle. Wakim¹⁴ pointed out that exercises which are regular and systematic, and of heavy nature will tend to thicken and toughen the sarcolemma of muscle fibers and increase the amount of connective tissue within the muscle. There is an increase in muscle size, but not an increase in the number of muscle fibers. DeLorme and Watkins¹⁵ further emphasize that there is an increase in the number of capillaries, and the content of muscle hemoglobin, phosphocreatine, and glycogen.

When systematic progressive exercise is carried on for a sufficiently long period of time, ability to do work is

¹² T. S. Robertson and J. M. Hawk, "Corrective Therapy in the Surgical Knee," The Journal of the Association for Physical and Mental Rehabilitation, Vol. 6, No. 1, September-October, 1952, p. 7.

¹³ The Knee, (Gardner, Kansas: The Cramer Chemical Company, no date) p. 23.

¹⁴ K. G. Wakim, "The Physiological Aspects of Therapeutic Physical Exercise," The Journal of the American Medical Association, 142: 2: January 14, 1950, pp. 104-105.

¹⁵ T. L. DeLorme, and A. L. Watkins, Op. Cit., p. 14.

augmented.¹⁶ It is further determined that when graphed against time, the slope gradient of the training curve will vary from individual to individual as well as the peak development attainable.

Studies related to weight training. Chui¹⁷ studied twenty-three subjects engaged in weight training two to three times weekly for one hour, compared with twenty-two subjects participating in a required physical education program. The study hoped to ascertain some pertinent facts covering the effects systematic weight training had on athletic power. The weight training subjects showed a slight improvement over the required physical education group in body weight, the Sargent jump, the eight and twelve pound shot put, and sixty yard dash. In the sixty yard dash the weight training group improved speed of 0.33 seconds. The mean improved from 7.9 to 7.57 seconds. One subject lost in speed 0.1 seconds. The physical education group's speed went from 8.05 to 8.1 seconds showing loss of speed of 0.05 seconds. Chui concluded that the subjects engaged in weight training improved over the control group and that results indicated the probability of

¹⁶ T. L. DeLorme and A. L. Watkins, Loc. Cit.

¹⁷ Edward Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, 21: October, 1950, pp. 188-194.

increasing speed through systematic weight training, although no statistical significance was shown.

Capen¹⁸ in a similar experiment compared a weight training group to a required physical education group. The weight training group showed greater general improvement in muscular strength, although there were no statistically significant differences between the two groups in muscular strength (McCloy's Revision), muscular endurance (chinning, push-ups, sit-ups, and squat jumps), and circulo-endurance (300 yard shuttle run) or in athletic power. The weight training group did, however, excel the required physical education group in all final scores, though not significantly due to the difference in initial scores. Capen concluded that the weight training group improved more in speed events than the required physical education group.

Zorbas and Karpovich¹⁹ studied six hundred men, ages 18 to 30 years, in an effort to determine the effects of training with weights on speed of muscular contraction. Two groups were used, the control group consisted of 300 men who never indulged in weight training, the experimental group consisted of 300 men who had participated in weight training for a minimum of six months and still were engaged in this activity.

¹⁸ E. K. Capen, "The Effects of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, 21: May, 1954, pp. 83-93.

¹⁹ W. S. Zorbas and P. V. Karpovich, "The Effect of Weight Lifting upon the Speed of Muscular Contractions," Research Quarterly, 22: May, 1951, pp. 145-148.

A specially constructed apparatus for recording speed of rotary movements of the arm was used for measurement. Each group had two trials with three minutes of rest between tests. The lowest recorded time in seconds was used. The weight lifting group was concluded to be faster in speed than the non-lifters, although no statistical significance was shown.

DeLorme, Ferris, and Gallagher²⁰ studied the effects of progressive resistance exercise on muscle contraction time. Elbow flexion and knee extension were studied in ten adolescent boys. Two groups consisting of five boys in an exercise group and five boys as controls were used. The exercise group was given progressive resistance exercise four times a week for four months. Elbow flexion and knee extension was measured on an electric clock calibrated in and accurate to within 1/100ths seconds. One R.M.'s were determined for biceps, knee extension, and hip-knee extension, while circumferential upper arm and thigh measurements at the beginning and end of the experimental period were taken. It was concluded that following the progressive resistance exercise period there was an increase in circumferential measures and a considerable increase in knee extension and elbow flexion one R.M.

²⁰ T. L. DeLorme, B. G. Ferris, and J. R. Gallagher, "Effects of Progressive Resistance Exercise on Muscular Contraction Time," Archives of Physical Medicine, 33: February, 1952, pp. 86-92.

The results of the post-exercise contraction time tests showed no evidence of slower times for the exercise group. No statistical significance was shown in this study.

Wilkins²¹ tested three groups as a means of finding the effects of weight training on speed of movements. The first group consisted of an elementary weight lifting class with no previous experience; the second group was made up of chronic weight lifters with an average of two and a half years experience; the third group, a control group, was taken from an elementary swimming class and a golf class.

All groups were tested on an arm movement recording apparatus. A bicycle crank with a radius of 7-1/4 inches was mounted on a frame and attached to the wall. The axis of the crank was 58 inches from the floor. There was no resistance other than the ball bearings used. Hand grips were made from the taped pedal sleeves. An electric counter set at fifteen second intervals was used to count the number of revolutions the subjects made. Both hands were used. The elementary weight lifters and the control group improved the same from the first test to the retest. The trend of data appears to be toward weight training improving speed.

²¹ B. M. Wilkins, "The Effects of Weight Training on Speed of Movement," Research Quarterly, 23: October, 1952, pp. 361-369.

Masley, Hairabedian, and Donaldson²² working with three groups; a beginning weight lifting class, a volley ball class, and a sports lecture class, studied the effect of systematic weight training on coordination and speed of movement. Speed was determined by twenty-four clockwise revolutions of the arm in a frontal plane in seconds. The apparatus used was similar to the hand crank of Zorbas and Karpovich.²³ The coordination test consisted of a foil test at a copper disc for speed and accuracy. Strength was tested by McCloy's revision of Roger's Strength Index. The weight training class improved in strength, speed, and coordination over the two other groups, although no statistical significance was shown. It was concluded that weight training had no apparent deleterious effect on the subjects.

²² J. W. Masley, A. Hairabedian, and D. N. Donaldson, "Weight Training in Relation to Strength, Speed, and Coordination," Research Quarterly, 24: October, 1953, pp. 308-315.

²³ W. S. Zorbas and P. V. Karpovich, Op. Cit., pp. 146-147.

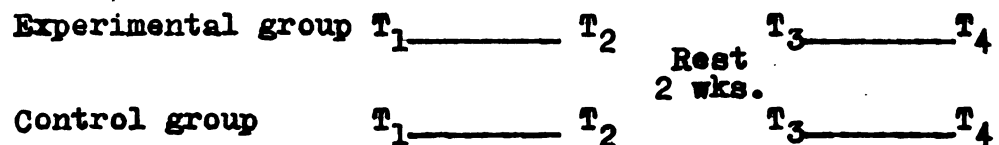
CHAPTER III

RESEARCH METHODS

This study was designed to determine the effect of progressive resistance exercise on quadriceps development and sprint running time. In addition to determining the effect of progressive resistance exercise on sprint running time, it was hoped that some determination could be made of the amount of quadriceps weight training which could be safely given athletes dependent on running speed without being deleterious to them.

I. SOURCE OF DATA

Method. The experimental method of research was used as diagramed:



The subjects were matched on their respective seventy-five yard times. The times used for matching purposes were the best of two trials.

Selection of measures. The twenty, as well as the seventy-five yard dash, was used to gain further insight into the effects the weight training had on sprint running. The cable tensiometer strength measure was utilized for both groups

and the one R.M. measure as an additional strength measure for the experimental group.

Selection of subjects. A large number of subjects were tested at the beginning of the experiment. The subjects finally selected consisted of Michigan State University freshmen track candidates and members of an individual athletic (track and field class) physical education class. Two groups of matched subjects in seventy-five yard dash time were selected from these tests.

The experimental group consisted of two freshmen track candidates and two members of a track and field class. The control group consisted of one freshman track candidate and three members of a track and field class. All subjects were participating in training for track.

The experimental factor. A progressive resistance exercise program for quadriceps development was set up for each subject in the experimental group. The program consisted of the experimental group meeting four days a week and performing knee extension exercise on both right and left legs. The exercise was accomplished by determining the one R.M. for each subject, subtracting five pounds, and having the subject lift this weight for three sets of ten repetitions with a rest between each set.¹

¹ K. K. Klein and E. Johnson, "Research: A Method of Determining the Maximum Load for Ten Repetitions in Progressive Resistance Exercise for Quadriceps Development," Journal of Physical and Mental Rehabilitation, 7: July-August, 1953, p. 8.

The control group did not participate in any weight training program but merely performed in their track training program.

Testing routine. All subjects met Wednesday of each week for testing on the following measures: 1) thigh girth measurement, 2) cable tension strength (right and left leg), and Friday for testing, 3) maximum strength (experimental group), 4) twenty yard dash, and 5) seventy-five yard dash.

The experiment was conducted for seven complete weeks with a two week layoff between week four and week five. The two week layoff was principally brought about because of a between school term vacation. At the end of the two week layoff, training and testing was resumed. The experiment was stopped at the end of seven weeks on the recommendation of Dr. Feurig,² team physician at Michigan State University, because of his feeling that the heavy weights (190 pounds) being used in the progressive resistance exercises (unilateral) might cause a slipping of the tibial tuberosity.

² James Feurig, M. D., Team Physician, Michigan State University.

II. TESTING TECHNIQUES

Thigh girth measurement. The eight subjects were measured for quadriceps girth development of both right and left legs. An anatomical mark was determined six inches above the patella and was held constant throughout the study. The subjects were instructed to stand and set the quadriceps muscles. The measurement was taken with a tape measure and the circumference of each leg was read in inches. The measurement was made with the tape tight over contracted muscles.

Cable tension strength. Cable tension strength measures were made exactly as described by Clarke.³ See Figures 1 & 2) Clarke⁴ found the coefficient of objectivity for this test to be between .92 and .97.

Strength measurement (One R.M.). Each of the experimental subjects were measured weekly for maximum strength by one R.M. knee extension lift. A one R.M. was determined for both the right and left leg. The one R.M. determination was performed as prescribed by Klein and Johnson.⁵

³ H. H. Clarke, Cable Tension Strength Tests, (Chicoppe, Massachusetts: Brown-Murphy Co., 1952), pp. 31.

⁴ H. H. Clarke, "Objective Strength Tests of Affected Muscle Groups Involved in Orthopedic Disabilities," Research Quarterly, 19: May, 1948, pp. 118-147.

⁵ K. K. Klein and E. Johnson, Loc. Cit.

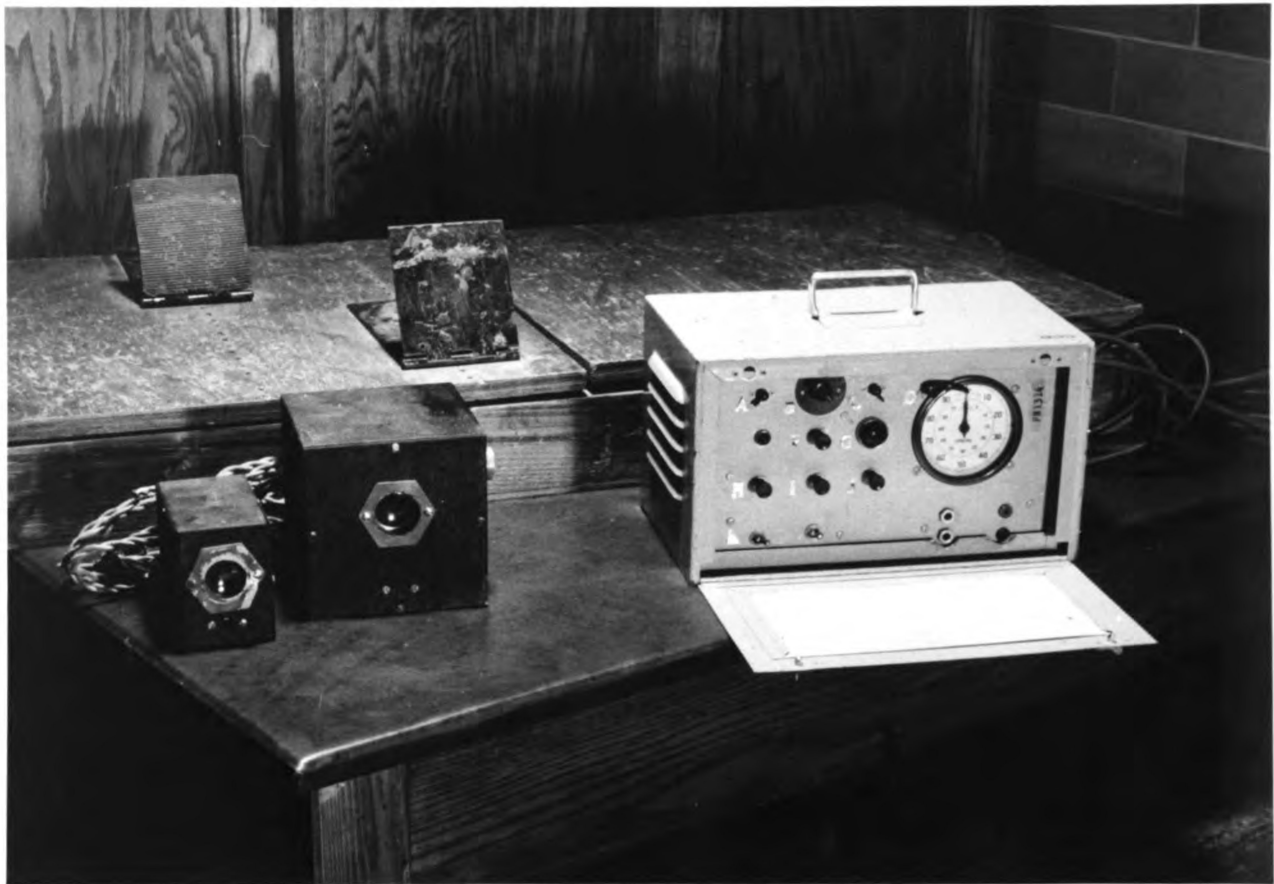


FIGURE 1

TIMING EQUIPMENT USED DURING THE EXPERIMENT

Back row: Starting blocks attached to platform.

Front row: Photoelectric Unit and Timing Unit.

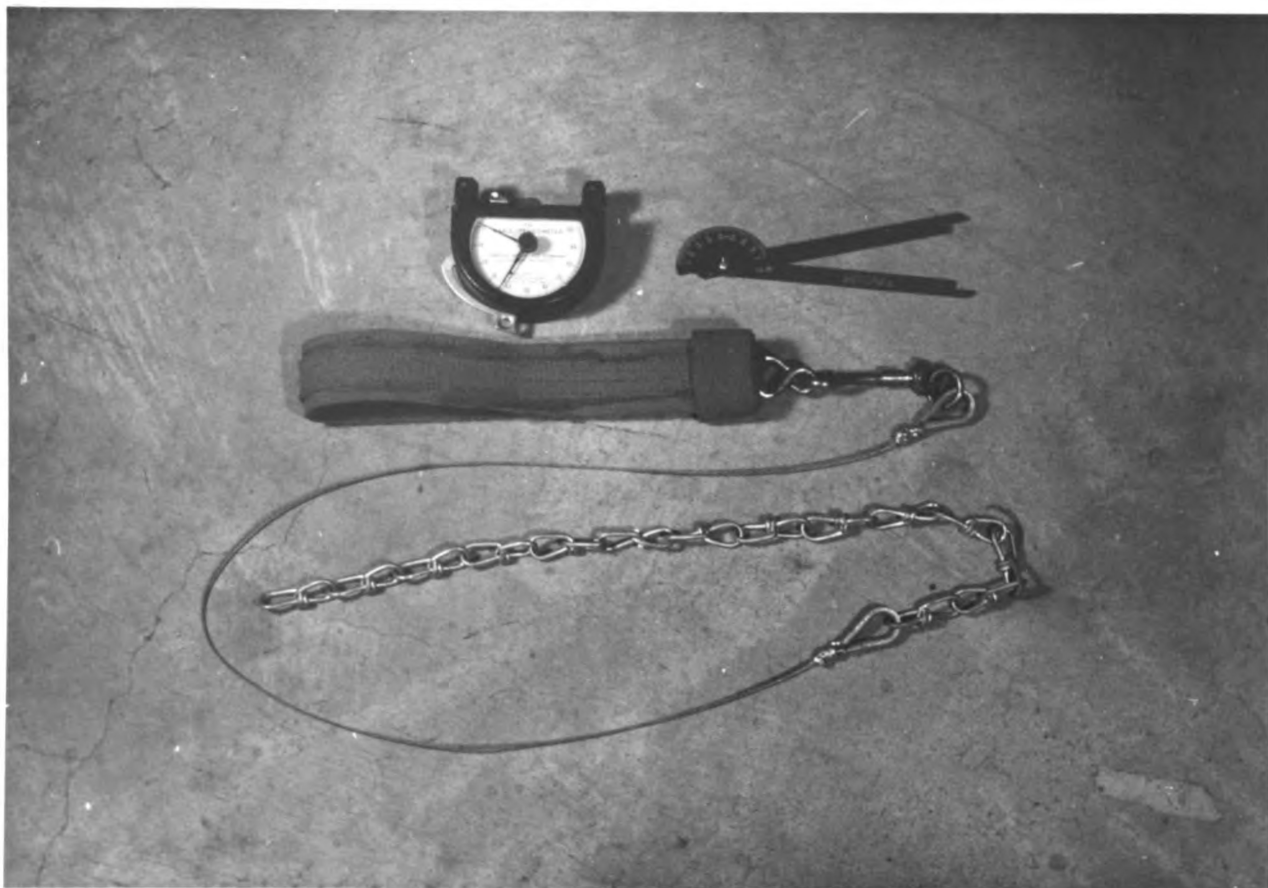


FIGURE 2

**CABLE TENSION STRENGTH TEST EQUIPMENT
USED DURING THE EXPERIMENT**

Back row from left to right: Tensiometer and goniometer.

Front row: Pulling strap with wire and chain attached.

Twenty and seventy-five yard dash. The eight subjects each Friday were tested for time in both the twenty and seventy-five yard dash and the time was recorded.* Each subject ran three twenty-yard dashes, one at a time, and an average of the three times were recorded. The seventy-five yard dash was recorded by taking the best time of two trials.

Timing device. The timing device developed by Montoye, et al.,⁶ was used. The subject took his position on the starting blocks, depressing a micro-switch. A pre-set button on the timer was set and as the subject left the starting blocks the depressed micro-switch released, starting the electric timer. As the subject crossed the electric eye beam, at the finish line, the current was cut stopping the electric timer. By testing in this manner starting times were not involved, only running times were recorded.

Method of exercise. Knee extension with overload produced by boot with weights was used as described by DeLorme⁷, with the following exception: A maximum single lift capacity was determined for each of the four subjects on right and left

* See Appendix

⁶ H. J. Montoye, et al., "An Electric Track and Reaction Timer," FIEP-Bulletin, 2: 1954, pp. 1-6.

⁷ T. L. DeLorme and A. L. Watkins, "Technics of Progressive Resistance Exercise," Archives of Physical Medicine, 29: May, 1948, p. 263.

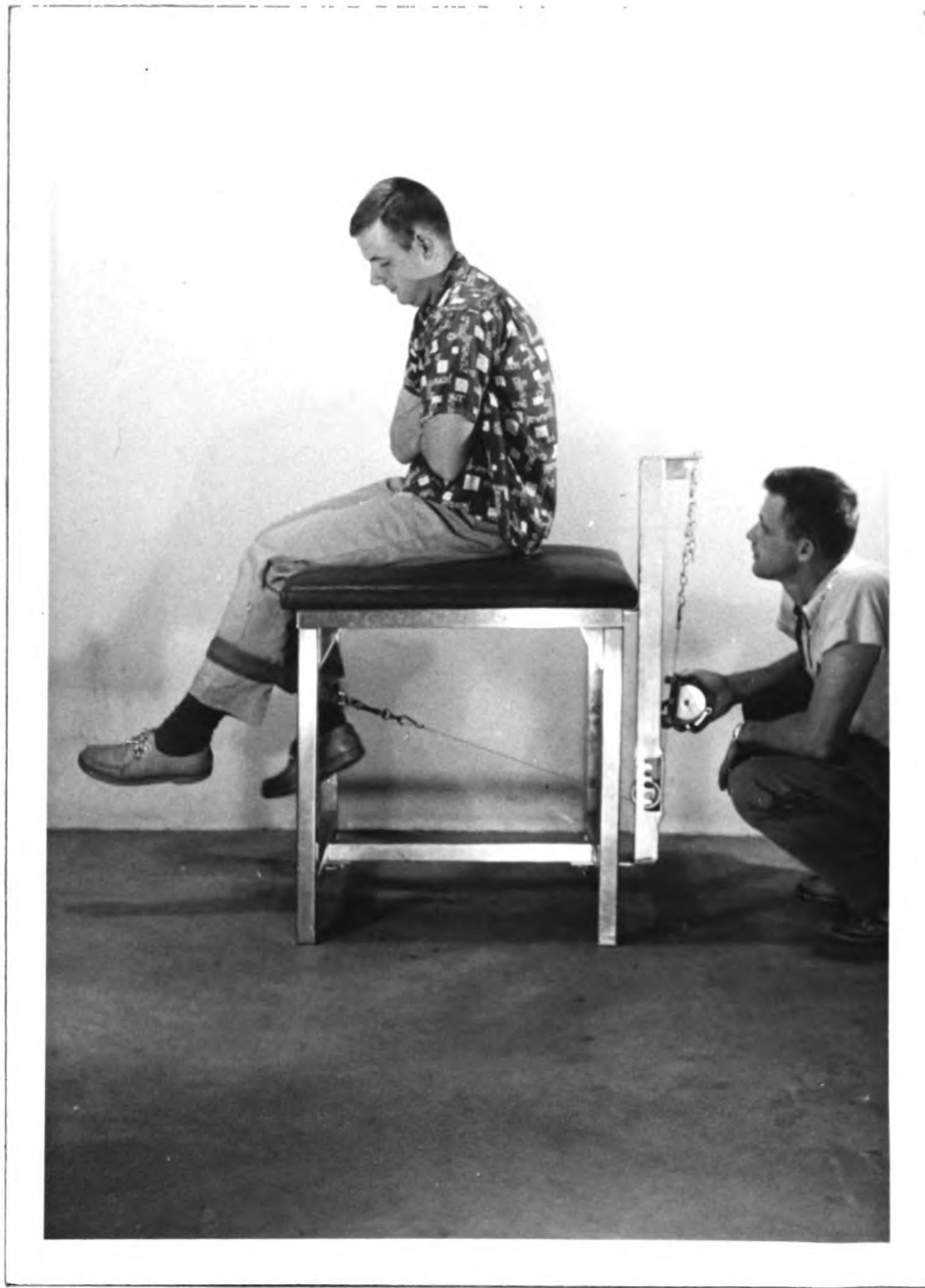


FIGURE 3
MEASURING CABLE TENSION STRENGTH

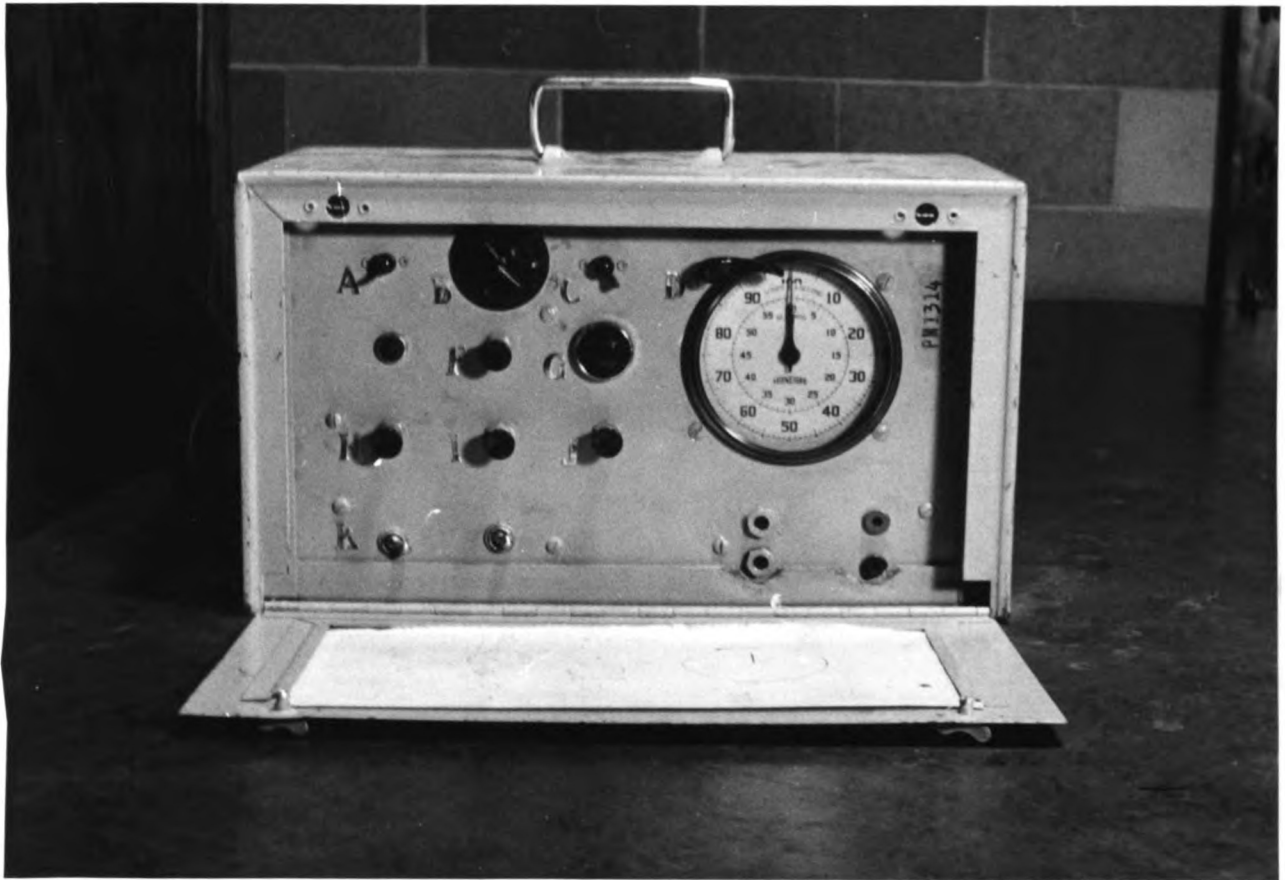


FIGURE 4
TIMING UNIT

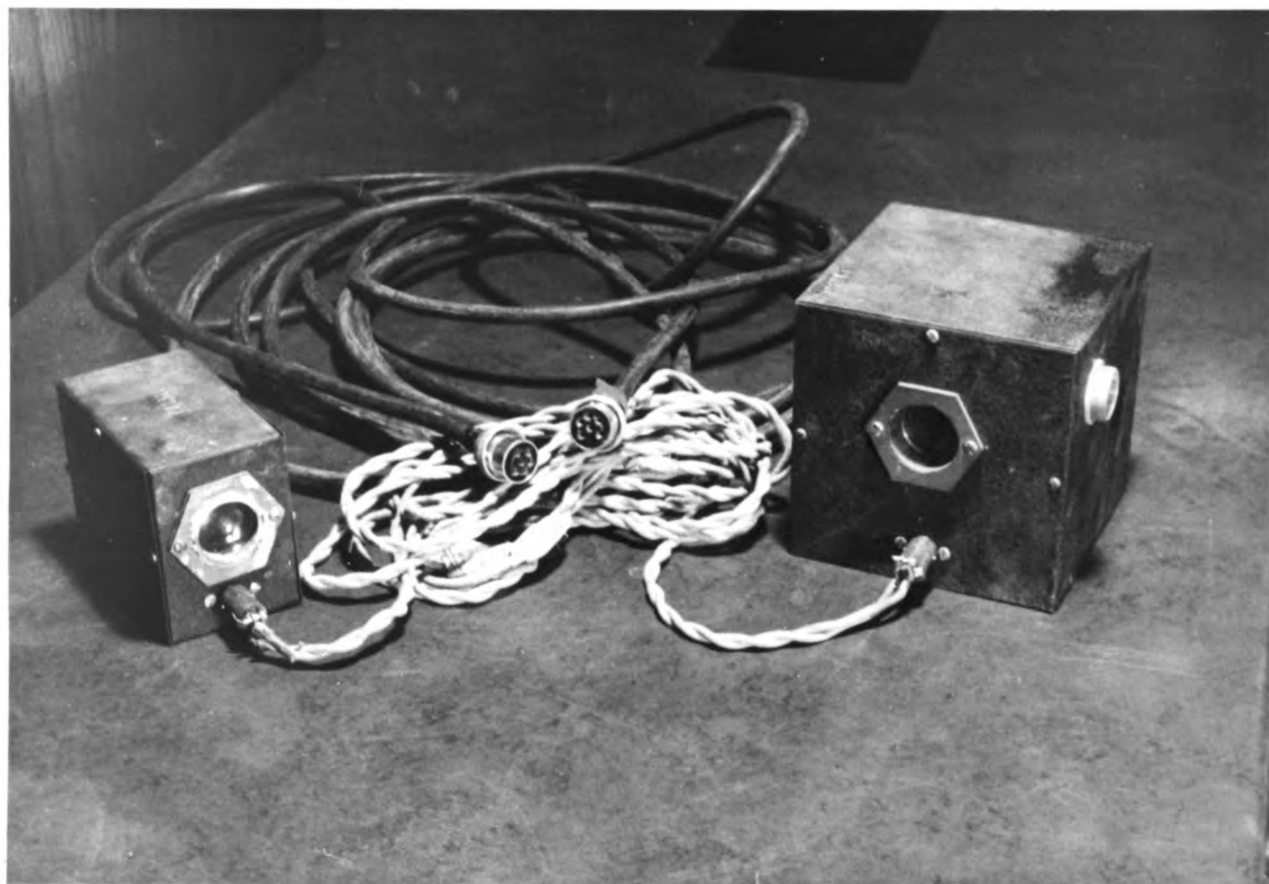


FIGURE 5
PHOTOELECTRIC UNIT

legs. Five pounds were deducted from the single lift to acquire ten R.M. capacity.⁸

All subjects participated in the track training program.

Statistical technique. The differences between the experimental and control groups and the differences within the groups from the initial through the final test were evaluated using the analysis of variance technique.⁹

Where the analysis of variance results were found to be significant, small sample "t" ¹⁰ tests were utilized to determine which differences were significant.

⁸ K. K. Klein and E. Johnson, Loc. Cit.

⁹ A. L. Edwards, Statistical Analysis, (New York: Rinehart and Company, 1946), p. 207.

¹⁰ Ibid., pp. 174-176.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The preceding chapters have discussed the statement of the problem, needs for the study, related studies, and the methods used in collecting the data. This chapter will give the results of the study indicated in the procedure described in Chapter III.

The purpose of this study was to evaluate the influence of progressive resistance exercise on quadriceps development and sprint running time. Because many believe that weight training is deleterious to speed, this study also hoped to determine the amount of progressive resistance exercise which may be given athletes dependent on running speed.

Methodology. The subjects used in this experimental study were divided into an experimental and control group. Four subjects were placed in each group, individually matched on their respective seventy-five yard sprint time.

The experimental group only participated in a weight training program, consisting of knee extension exercises. Both groups remained on a track training program. The testing program consisted of the following measures: 1) thigh girth measures, 2) cable tension strength (right and left leg),

3) maximum strength (experimental group only), 4) twenty-yard dash, and 5) seventy-five yard dash. All measures were taken weekly for seven weeks.

Treatment of data. All results were tabulated and differences within the groups from T_1 through T_4 were evaluated using the analysis of variance technique. The small sample "t" test was utilized for further analysis in all cases where the "F" values were significant.

Presentation of data. The data is presented graphically and discussed as to the trends, findings, and statistical significance. The presentation is divided into two categories (I) the testing results, and (II) discussion.

I. TESTING RESULTS

Seventy-five yard dash results. The results of the seventy-five yard dash are shown in Chart I.

The differences from T_1 to T_4 for each group were compared using the "F" test and were found not to be significantly ($F = 1.11$ with 3 df) different. The "F" value computed on the experimental group's data alone also was not significant ($F = 8.43$ with 12 df).

In the limitations of the study, Chapter I, it was brought out how difficult it is to determine whether the subjects are performing maximum lifts or maximum running speed. The psychological factor seems to be evident in this study.

Two subjects of the experimental group are questionable, although they stated they were performing maximum lifts and running maximum speed, the writer questions their performances. This observation, however, may or may not be correct. While the data bear it out, it is entirely possible that they were performing their best at the time but that there was inadequate motivation to stimulate them to better performances. An analysis of variance was calculated for between row values (subject's repeat test values), for the seventy-five yard dash. The "F" value found in this analysis of variance was 4.57, significant at the 5% level. The significance holds little meaning for the over-all study other than to substantiate the writer's observation as to the differences in subjects.

It is important to remember, however, that although no statistically significant improvement was found in the seventy-five yard dash results, the experimental group did not slow down in their time. The effects of progressive resistance exercise were not deleterious to them. The trends, in fact, are in the opposite direction (faster times) but not significantly so in this study.

Twenty yard dash results. The results of the twenty yard dash can be seen in Chart II, page 27.

The "F" value found in differences between groups was not significant ($F = 1.32$ with 3 df). The small sample "t" value also calculated for the experimental group only yielded a value of 3.31 not significant at the 5% level.

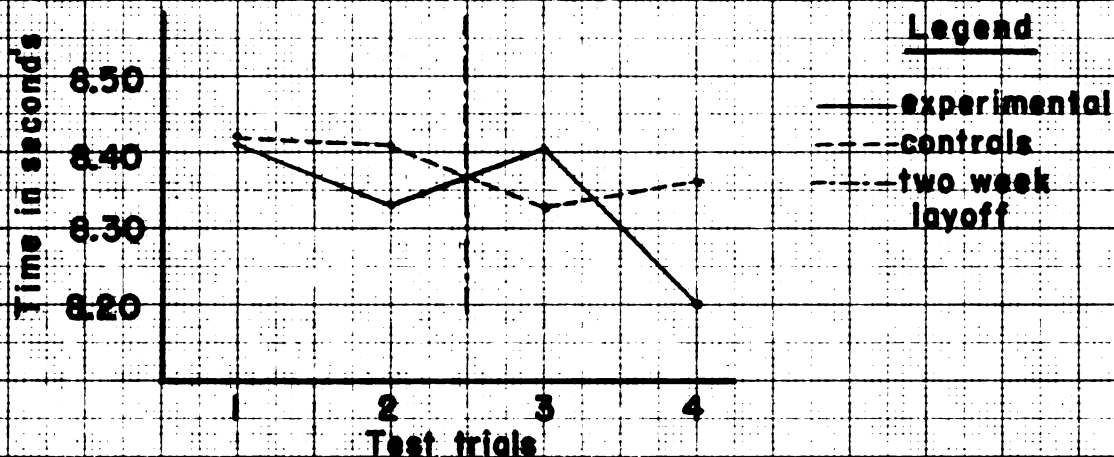


CHART I

TIME IN THE 75 YARD DASH
(MEAN SCORES)

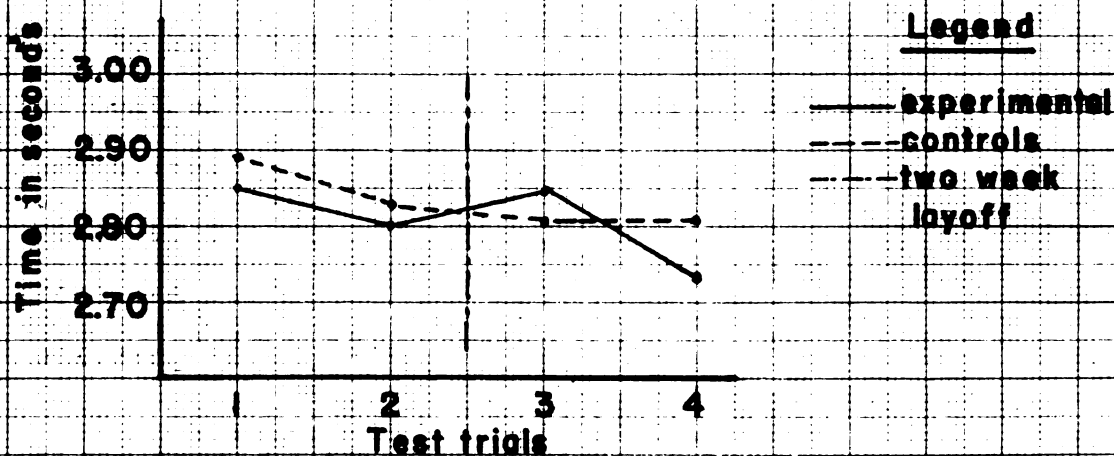
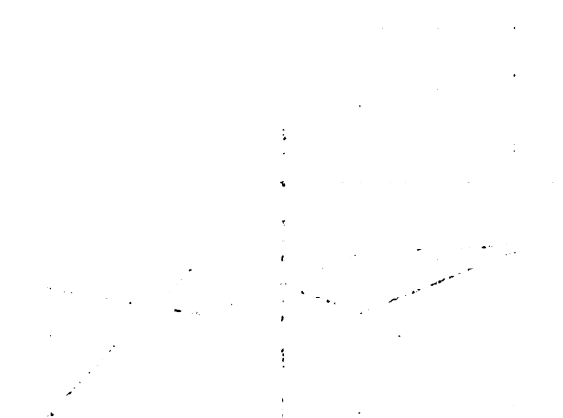


CHART II

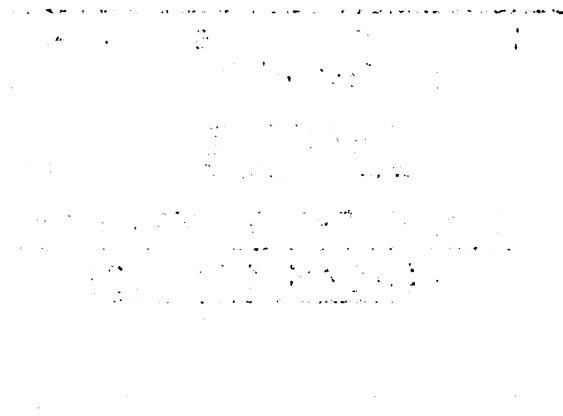
TIME IN THE 20 YARD DASH
(MEAN SCORES)

1. The first part of the report
 describes the general situation
 and the results of the
 investigation.



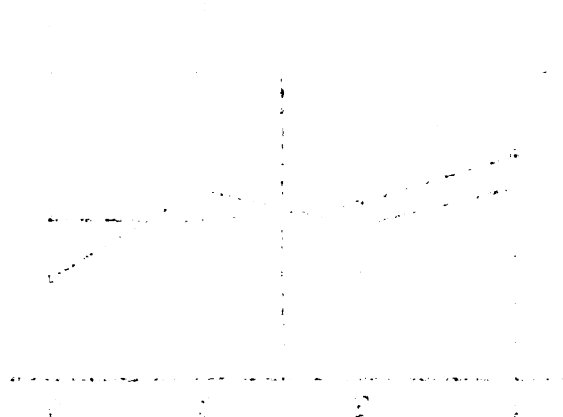
2. The second part of the report
 discusses the details of the
 investigation and the results of the
 analysis.

3. The third part of the report
 discusses the details of the
 investigation and the results of the
 analysis.



4. The fourth part of the report
 discusses the details of the
 investigation and the results of the
 analysis.

5. The fifth part of the report
 discusses the details of the
 investigation and the results of the
 analysis.



6. The sixth part of the report
 discusses the details of the
 investigation and the results of the
 analysis.

7. The seventh part of the report
 discusses the details of the
 investigation and the results of the
 analysis.



8. The eighth part of the report
 discusses the details of the
 investigation and the results of the
 analysis.

The small sample "t" test was worked out for the writer's interest in the twenty yard dash. The "t" value obtained in the T_1 versus T_2 in analysis for the experimental group was 6.0, significant at the 1% level. Comparing the T_4 results of the experimental group and control groups, a small sample "t" value of 3.95 (3 df) significant at the 5% level was obtained. The "t" test results in this study are confusing as the significance obtained in the small sample "t" tests were due not to significant differences in the mean, but rather because of the differences in the variances.¹ An indication of this was shown in the between row "F" test analysis of the seventy-five yard dash data.

In the twenty yard dash results as in the seventy-five yard results, a slight, but insignificant change was noted in the experimental group's speed. The mean score for the experimental group between T_1 and T_4 in twenty yard dash times were 2.85 to 2.73 seconds, an increase of speed of .15 seconds. The control group's time for T_1 and T_4 was 2.89 to 2.81 seconds respectively, an increase in speed of .09 seconds. The increase of the experimental group as compared to the control group was not statistically significant. The "F" obtained in analyzing the differences between groups was 1.32 (3 df).

Cable tension strength results. The results obtained in cable tension strength for the right and left legs are shown in Chart III and Chart IV.

¹ A. L. Edwards, Statistical Analysis, (New York: Rinehart and Company, 1946), p. 172.

The differences between groups using the "F" test was found for tension strength for both right and left legs. The "F" value found for the right leg was not significant ($F = 1.07$, 12 df). Likewise, the "F" value found for the left leg was not significant ($F = 1.11$, 3 df).

The analysis of variance was also computed independently for the experimental and control groups. The "F" value found for the experimental group for the right leg strengths, was significant at the 5% level ($F = 4.15$, 3 df). The "F" value calculated for the left leg results was not significant ($F = 2.75$, 3 df).

The "F" values for the control group showed no significance for the right leg results ($F = 2.7$, 3 df), but significance at the 5% level was obtained in the left leg data ($F = 3.56$, 3 df).

The control group was executing three maximum contractions once per week during the tensiometer testing. In the analysis of variance, the control group did increase strength significantly in the left leg, but not significantly in the right. It is possible the maximum contractions elicited during the tensiometer testing have biased this phase of the data. How much the data has been biased is not known but in the light of Hettinger and Muller's² work, it seems logical the three maximum contractions may explain the lack of significant differences in strength improvement.

² Th. Hettinger and A. E. Muller, "Muskelleistung und Muskeltraining," Arbeitsphysiologie, xv. No. 2: October, 1953, pp. 116-126.

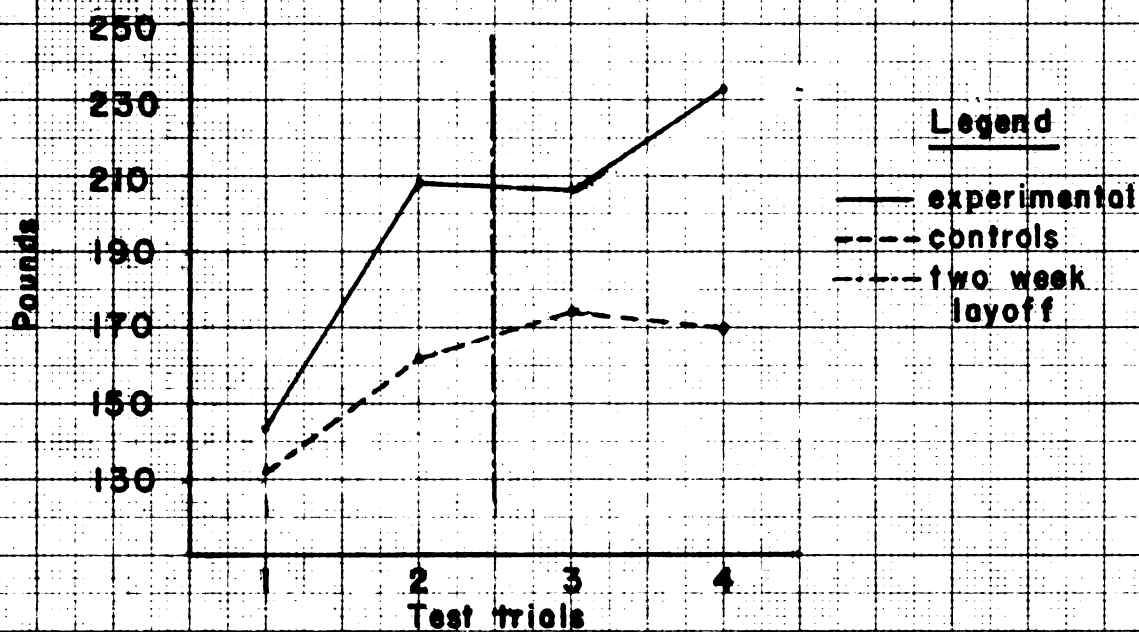


CHART III

**CABLE TENSION STRENGTH
RIGHT LEG (MEAN SCORES)**

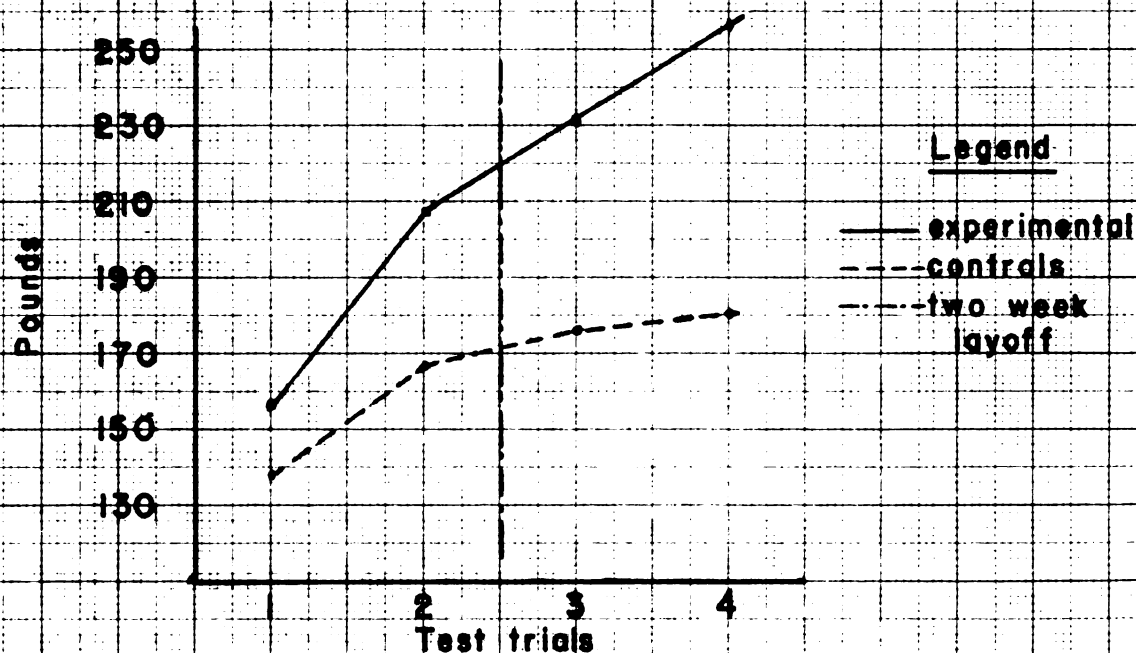
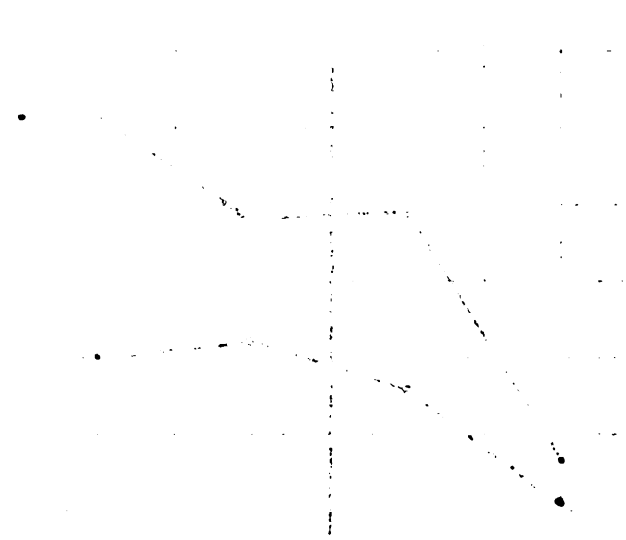


CHART IV

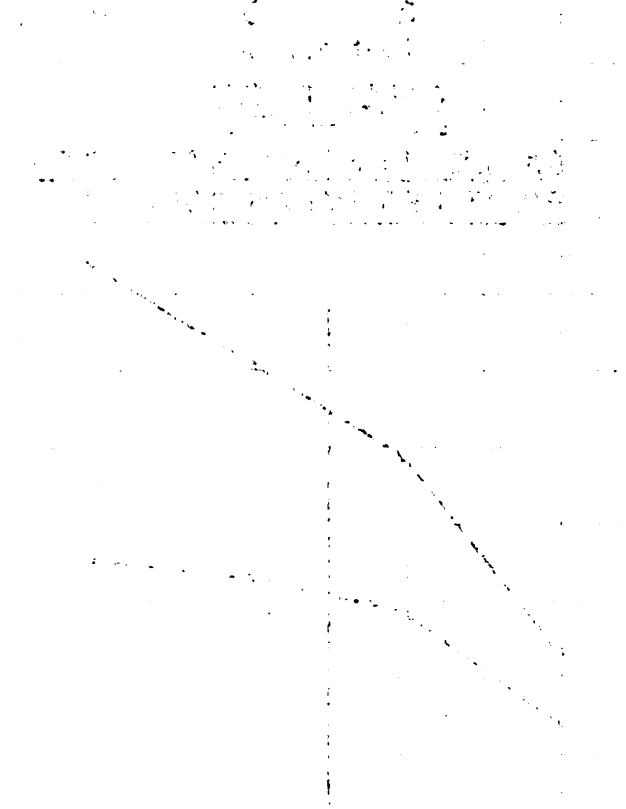
**CABLE TENSION STRENGTH
LEFT LEG (MEAN SCORES)**

1. The first part of the report
 2. The second part of the report
 3. The third part of the report
 4. The fourth part of the report
 5. The fifth part of the report
 6. The sixth part of the report
 7. The seventh part of the report
 8. The eighth part of the report
 9. The ninth part of the report
 10. The tenth part of the report



0.0
 0.1
 0.2
 0.3
 0.4
 0.5
 0.6
 0.7
 0.8
 0.9
 1.0

1. The first part of the report
 2. The second part of the report
 3. The third part of the report
 4. The fourth part of the report
 5. The fifth part of the report
 6. The sixth part of the report
 7. The seventh part of the report
 8. The eighth part of the report
 9. The ninth part of the report
 10. The tenth part of the report



0.0
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 1.0

1. The first part of the report
 2. The second part of the report
 3. The third part of the report
 4. The fourth part of the report
 5. The fifth part of the report
 6. The sixth part of the report
 7. The seventh part of the report
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 9. The ninth part of the report
 10. The tenth part of the report



0.0
 0.1
 0.2
 0.3
 0.4
 0.5
 0.6
 0.7
 0.8
 0.9
 1.0

One R.M. results. The results of the experimental groups one R.M. strength measures are shown in Chart V and Chart VI.

In calculating the analysis of variance for the experimental group one R.M. results, the "F" values were found to be highly significant for the right and left leg, 12.1 and 32.5 respectively at the 1% level with three degrees of freedom.

In order to determine where the significance was, small sample "t"'s were utilized. The small sample "t"'s calculated for the right leg one R.M. data yielded 4.76 (3 df) in T_1 versus T_2 data and 4.32 (3 df) in the T_1 versus T_4 data, both significant at the 5% level.

The small sample "t"'s calculated for the left leg one R.M. data yielded a 5.22 (3 df) in the T_1 versus T_2 data and 3.81 (3 df) in the T_1 versus T_4 data. Both values were significant at the 5% level.

The analysis of variance and small sample "t" tests indicate a significant increase in dynamic strength as measured by the one R.M. in the present study. It must be noted the one R.M. is a dynamic strength measure. The differences in the one R.M. and the static strength measure of the tensiometer are of extreme interest. The data raise the question of how valid the cable tensiometer data are of dynamic strength. It seems entirely possible that dynamic strength could improve and static strength remain approximately the same. This point merits further investigation.



CHART V

I.R.M. STRENGTH MEASUREMENT
RIGHT LEG (MEAN SCORES)

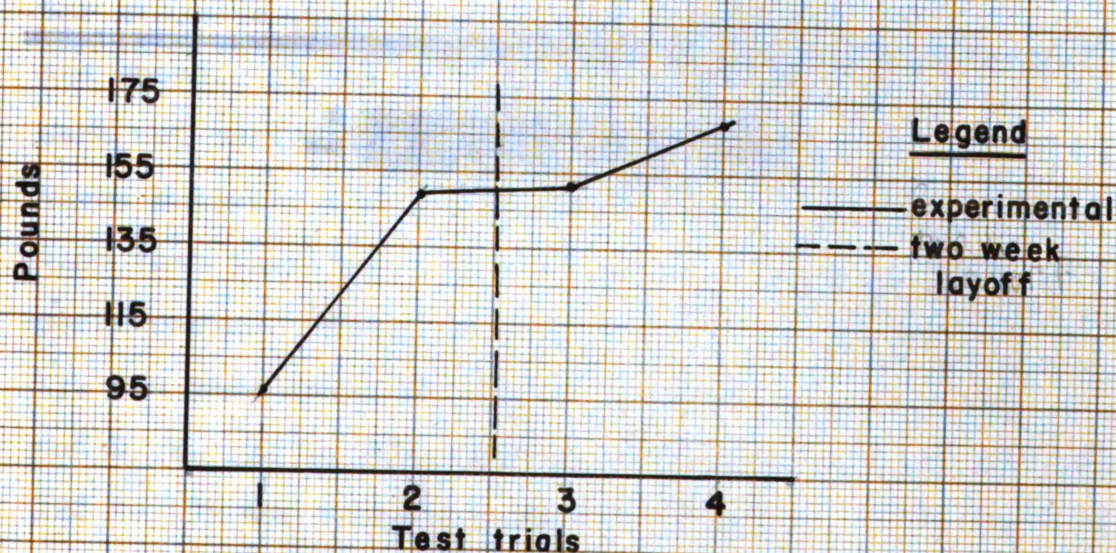


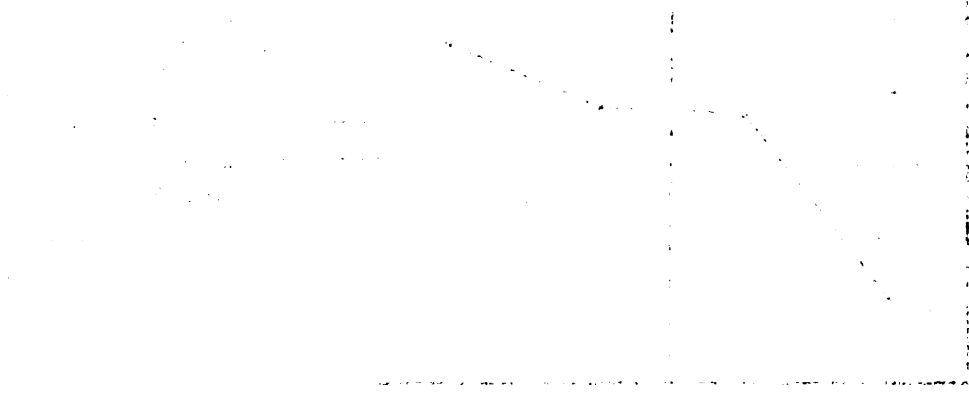
CHART VI

I.R.M. STRENGTH MEASUREMENT
LEFT LEG (MEAN SCORES)



100
200
300
400
500
600
700
800
900
1000

100
200
300
400
500
600
700
800
900
1000



100
200
300
400
500
600
700
800
900
1000

100
200
300
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500
600
700
800
900
1000

TABLE I
VALUES OF "F" TESTS

TESTS	Differences between groups	Experimental group data	Control group data
75 yard dash	1.11	8.43	
20 yard dash	1.32	3.31	
Tension strength			
Right leg	1.07	4.15*	2.27
Left leg	1.11	2.85	3.56*
One R.M.			
Right leg		12.05**	
Left leg		32.65**	

* Significant at 5% level.
** Significant at 1% level.

Thigh girth measures results. The thigh girth measures were not used because of their apparent unreliability. Though the measurements were made six inches above the top of the patella over contracted quadriceps with the tape pulled tight, they fluctuated and did not improve. The author observed the contracted quadriceps was higher on the leg during maximum contraction as the strength measures were increasing. How much this may have affected the girth measures is not known.

II. DISCUSSION

Two limitations of this study seemed to have some apparent effect on the results. The psychological factor was observed in the experimental group. Although all the subjects seemed to be performing maximum lifts and running maximum speed, two of the subjects showed very little improvement in both strength and speed. It was felt by the writer that these two subjects were not performing maximum lifts. It is possible that though these subjects were lifting what was maximum for them at the time that there was insufficient motivation to obtain maximum performances. Though all experimental subjects lifted equally, two made excellent improvements (subject E. C. 84 to 190 and D. W. 192 to 185.) and two little improvement (subject M. R. 122 to 155 and subject K. K. 100 to 152.). These results also added bias to the running times of the experimental group. Evidence to substantiate this observation was shown in the analysis of variance when differences between rows or subjects in the seventy-five yard dash times were calculated. The "F" value

of 4.57 (3 df) was significant at the 5% level, indicating a significant difference in subjects.

The other limitation came about in the control group. The control group, although not participating in progressive resistance exercise, did increase leg strength, due to performing three all out maximum contractions once a week in the tension strength test. The "F" value of the analysis of variance showed the control group to increase left leg strength 3.56 at the 5% level. In utilizing a small sample "t", a value of 4.2 was found significant at the 5% level in T_1 versus T_4 for the control group. This increase in strength may have had some bearing on running time.

The trend of the graphs on seventy-five and twenty yard dash times shows that the experimental made improvement in mean scores. The two week layoff had some effect on slowing the experimental group up in running time, although this was not statistically significant.

It can be determined that with seven weeks of progressive resistance exercise, the dynamic quadriceps strength as measured by the one R.M. measure can be significantly increased. The "F" values of 12.1 and 32.5 respectively for right and left legs, are significant at the 1% level with three degrees of freedom.

It is felt by the writer that if more all out efforts could be obtained from the subjects in both lifting and running, by using rewards or other motivational techniques, significant results would be obtained in running times. This is

substantiated by the improvements made by the two subjects, E. C. and D. W., who were obviously more interested.

Probably the most important single point in this study is that though one R.M. values as high as 190 pounds were obtained, which is a considerably heavier load than is used in progressive resistance exercise for the quadriceps group, the effect was not deleterious. The trends, in fact, even at these loads were toward faster not slower times. These results are similar to those obtained in the earlier weight lifting studies.^{3, 4, 5, 6, 7}

The tensiometer results are of extreme interest. An experimental group lifted maximally for seven weeks but there was no significant difference between groups. This failure to obtain significance is possibly explained by three maximum contractions executed once per week. Hettinger and Muller's⁸

³ Edward Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, 21: October, 1950, pp. 188-194.

⁴ E. K. Capen, "The Effects of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, 21: May, 1954, pp. 83-93.

⁵ W. S. Zorbas and P. V. Karpovich, "The Effect of Weight Lifting upon the Speed of Muscular Contractions," Research Quarterly, 22: May, 1951, pp. 145-148.

⁶ B. M. Wilkins, "The Effects of Weight Training on Speed of Movement," Research Quarterly, 23: October, 1952, pp. 361-369.

⁷ J. W. Masley, A. Hairabedian, and D. N. Donaldson, "Weight Training in Relation to Strength, Speed, and Coordination," Research Quarterly, 24: October, 1953, pp. 308-315.

⁸ Th. Hettinger and A. E. Muller, Loc. Cit.

study lends further insight into this explanation. What remains unexplained, however, is why the one R.M. (dynamic lifting) values increased significantly in the experimental group and the tensiometer values were significant for the right leg only. It would seem from the data that it is possible to increase dynamic strength without significant changes in static strength. The writer feels the data in this study are insufficient to draw conclusions but they are certainly sufficient to raise the question for further investigation.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary. The purpose of this study was to determine the influence of progressive resistance exercise on quadriceps development and sprint running time.

Two groups of four subjects each matched in seventy-five yard sprint times were tested in this study. The experimental group consisted of two freshmen track candidates and two members of a track and field class. The experimental group participated in a progressive resistance exercise program. This program consisted of meeting four days a week and performing a knee extension exercise for both right and left legs. At the end of each week a 1 R.M. was determined and recorded.

The control group consisted of one freshmen track candidate and three members of a track and field class who did not participate in progressive resistance exercise. All subjects participated in daily track training and were tested Wednesday and Friday of each week for seven weeks. A two week layoff was brought about because of a between term school vacation and took place between week four and week five.

The testing program consisted of measuring each Wednesday, thigh girth development and tension strength. Friday was set aside for testing seventy-five yard dash times and also

determining and recording of one R.M. for the experimental group only. The data was presented graphically and tested statistically by the analysis of variance. When "F" values were significant, small sample "t" tests were utilized to further analyze the data.

Limitations of this study may have added some bias to the data because of the psychological factor involved in doing maximum lifts and running maximum speed. Also increase of strength may be obtained by performing a maximum contraction once per week in tension strength.

Conclusion. The following conclusions are drawn on the basis of the data presented. Any interpretation of these conclusions should be in light of the limitations of the study.

1. Progressive resistance exercise, even above the weight loads used in knee exercises, had no deleterious effect on sprint running times in either the twenty or seventy-five yard dashes. The trends, in fact, were toward faster times but insignificantly so.

2. No significant differences between groups were found in knee extension strength, as measured by the cable tensiometer. Possible reasons for these results have been discussed in the previous chapter.

3. There was a significant increase ($F = 12.1$ and 32.5 at the 1% level) in one R.M. values from initial to final test in the experimental group. On the basis of the present study

no conclusions can be drawn as to whether this significant increase was due to running or weight training.

Recommendations. The recommendations of this study are as follows:

1. Due to the small number of subjects used in this study, it is recommended that the same study should be repeated with more subjects.
2. It is recommended that a similar study be extended for a greater length of time.

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APPENDIX

MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH
AND RECREATION FOR MEN

GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

DATE OF TABULATION MAY 18, 1955

TABULATED BY RICHARD C. QUELLETTE

TOPIC THE EFFECTS OF QUADRICEPS DEVELOPMENT ON SPRINT RUNNING TIME

		75 YARD TIMES (SECONDS)				CABLE TENSION STRENGTH, RIGHT LEG (POUNDS)				CABLE TENSION STRENGTH, LEFT LEG (POUNDS)					
		1st. week	2nd. week	3rd. week	4th. week	5th. week	6th. week	7th. week	8th. week	9th. week	10th. week	11th. week	12th. week	13th. week	14th. week
1 EXPERIMENTAL															
2 E.C.	8.23	8.13	8.31	8.03	8.09	7.98	7.92								
3 D.W.	7.98	7.91	7.92	7.85	7.78	7.79	7.71								
4 M.R.	8.67	8.75	8.76	8.72	8.74	8.74	8.68								
5 K.K.	8.75	8.53	8.72	8.72	8.98	8.48	8.50								
6 MEANS	8.41	8.33	8.43	8.33	8.40	8.25	8.20								
7															
8															
9 CONTROLS															
10 D.C.	8.25	8.31	8.41	8.30	8.16	8.09	8.16								
11 R.S.	7.99	8.18	7.97	8.15	8.01	8.17	8.10								
12 W.N.	8.67	8.70	8.30	8.38	8.55	8.44	8.43								
13 D.Ch.	8.75	8.87	8.94	8.81	8.61	8.68	8.74								
14 MEANS	8.42	8.52	8.38	8.41	8.33	8.35	8.38								
15															
16															
17															
18															
19 EXPERIMENTAL															
20 E.C.	2.75	2.71	2.75	2.74	2.76	2.67	2.64								
21 D.W.	2.78	2.73	2.69	2.75	2.71	2.72	2.70								
22 M.R.	2.89	2.89	2.85	2.87	2.84	2.81	2.79								
23 K.K.	2.97	2.84	2.87	2.86	3.08	2.85	2.80								
24 MEANS	2.85	2.76	2.81	2.79	2.85	2.76	2.72								
25															
26															
27 CONTROLS															
28 D.C.	2.76	2.76	2.72	2.75	2.74	2.73	2.72								
29 R.S.	2.88	2.80	2.79	2.77	2.77	2.77	2.72								
30 W.N.	2.92	2.95	2.84	2.89	2.91	2.95	2.89								
31 D.Ch.	3.00	2.97	2.80	2.91	2.83	2.88	2.90								
32 MEANS	2.89	2.88	2.79	2.83	2.81	2.82	2.81								
33															
34															
35															

MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH
AND RECREATION FOR MEN
GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

DATE OF TABULATION MAY 18, 1955

TABULATED BY RICHARD C. QUELLETTE

TOPIC THE EFFECTS OF QUADRICEPS DEVELOPMENT ON SPRINT RUNNING TIME

I.R.M., RIGHT LEG (POUNDS)										THIGH GIRTH MEASURES, RIGHT LEG (INCHES)										THIGH GIRTH MEASURES, LEFT LEG (INCHES)									
1st. week	2nd. week	3rd. week	4th. week	5th. week	6th. week	7th. week				1st. week	2nd. week	3rd. week	4th. week	5th. week	6th. week	7th. week				1st. week	2nd. week	3rd. week	4th. week	5th. week	6th. week	7th. week			
1 EXPERIMENTAL										EXPERIMENTAL										EXPERIMENTAL									
2	E.C.	84	125	135	136	157	171	180		E.C.	20.	21.5	22.	22.25	22.25	22.5				E.C.	20.	21.5	22.	22.25	22.25	22.5			
3	D.W.	92	123	140	152	165	170	185		D.W.	19.75	19.75	20.75	20.5	20.5	20.				D.W.	19.75	19.75	20.75	20.5	20.5	20.			
4	M.R.	122	136	140	141	141	151	155		M.R.	19.25	19.5	19.375	19.25	19.	19.25				M.R.	19.25	19.5	19.375	19.25	19.	19.25			
5	K.K.	100	128	136	142	140	142	152		K.K.	20.5	20.75	20.5	20.75	20.75	21.				K.K.	20.5	20.75	20.5	20.75	20.75	21.			
6	MEANS	99.5	128.5	137.8	142.8	150.8	158.5	168		MEANS	19.875	20.375	20.656	20.625	20.625	20.687				MEANS	19.875	20.375	20.656	20.625	20.625	20.687			
7																													
8																													
9 CONTROLS—NO I.R.M. RECORDED FOR THIS GROUP										CONTROLS										CONTROLS									
10										D.Co.	19.	19.	18.75	19.25		19.				D.Co.	19.	19.	18.75	19.25		19.			
11										R.S.	20.	20.5	20.25	20.5		20.				R.S.	20.	20.5	20.25	20.5		20.			
12										W.N.	19.5	20.	20.	20.		20.				W.N.	19.5	20.	20.	20.		20.			
13 EXPERIMENTAL										EXPERIMENTAL										EXPERIMENTAL									
14	E.C.	84	116	125	138	163	185	190		D.Ch.	21.25	21.25	21.	21.		19.				D.Ch.	21.25	21.25	21.	21.		19.			
15	D.W.	107	128	145	161	160	170	177		MEANS	19.937	20.562	20.	20.125		19.5				MEANS	19.937	20.562	20.	20.125		19.5			
16	M.R.	122	145	145	151	151	151	155																					
17	K.K.	105	123	131	131	130	142	150																					
18	MEANS	104.5	128	136.5	150	151	162	168																					
19																													
21 CONTROLS—NO I.R.M. RECORDED FOR THIS GROUP										EXPERIMENTAL										EXPERIMENTAL									
22										E.C.	19.5	21.75	21.5	21.75		22.				E.C.	19.5	21.75	21.5	21.75		22.			
23										D.W.	20.25	20.25	20.75	20.75		20.5				D.W.	20.25	20.25	20.75	20.75		20.5			
24										M.R.	19.5	20.	19.75	19.5		19.				M.R.	19.5	20.	19.75	19.5		19.			
25										K.K.	21.	21.25	21.25	21.25		20.5				K.K.	21.	21.25	21.25	21.25		20.5			
26										MEANS	20.0625	20.75	20.75	20.9125		20.5				MEANS	20.0625	20.75	20.75	20.9125		20.5			
27																													
28 CONTROLS										CONTROLS										CONTROLS									
29										D.Co.	19.25	19.25	18.75	19.25		19.				D.Co.	19.25	19.25	18.75	19.25		19.			
30										R.S.	20.75	20.5	20.25	20.75		20.				R.S.	20.75	20.5	20.25	20.75		20.			
31										W.N.	20.75	20.5	20.5	20.5		21.				W.N.	20.75	20.5	20.5	20.5		21.			
32										D.Ch.	21.5	21.5	21.25	21.25		20.				D.Ch.	21.5	21.5	21.25	21.25		20.			
33										MEANS	20.5625	20.4375	20.1875	20.4375		20.				MEANS	20.5625	20.4375	20.1875	20.4375		20.			
34																													
35																													

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