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Leg Strength, Leg Power, and Sprinting Speed as Affected by a Select Weight Training Program

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LEG STRENGTH, LEG POWER, AND SPRINTING SPEED AS AFFECTED BY A SELECT WEIGHT TRAINING PROGRAM

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor — Date

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P.D.F.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

CHAPTER I

INTRODUCTION

Significance of the Study

In athletic activities, strength, speed, and power are important factors that determine how effective and efficiently an individual will perform. Present day coaches realize that in order to have championship athletes and teams, the individual athlete must have muscular strength, speed, and power sufficient to meet the challenges of prolonged strenuous practice and competition. Other things being equal, the faster and stronger man will be more effective in athletics than the slower, weaker man.

Kirkley indicates that the use of weights for improving one's ability in various sports and games is now largely accepted by the world's leading coaches.[1] The myth that weightlifting will hamper speed has been argued, but today many coaches and sport scientists feel that an increase in strength through the use of weights will also increase the speed of muscular contractions.[2]

Strenuous sports make heavy physical demands on participants. Sheer strength, speed, power, and quickness in addition to skill are essential for an individual to be an adequate competitor. Leg strength,

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[1] George Kirkley, Weightlifting and Weight Training (New York: ARC Books, Inc., 1970), pp. 63-64.

[2] William S. Zorbas and Peter V. Karpovich, "The Effect of Weightlifting Upon the Speed of Muscular Contractions," Research Quarterly, 21:145-148, May, 1951.

explosive power, and sprinting speed are valuable assets to all athletes, and coaches are constantly searching for new methods of improving these qualities in their players. Carnes stated that an increase in an athlete's leg power may also help him increase his speed.[3] Roy has contended that leg strength is the most important element in explosive power.[4]

In light of the evidence that over-all strength, power and speed may be increased by a select weight training program, the investigator felt that a study on the effects of weight training on only the legs would be feasible. Questions asked are: does exercising one leg at a time produce greater strength improvement than exercising both legs at the same time? Does a weight training program specifically designed for strengthening only the legs develop power and increase sprinting speed? Is the time required to exercise one leg at a time administratively feasible? Hopefully such a study will provide objective and practical knowledge about off-season training programs and their relation to leg strength, leg power, and sprinting speed.

Statement of the Problem

The purpose of this investigation was to determine what effects a select weight training program consisting of exercises for each leg individually would have on leg strength as compared to the same program exercising both legs simultaneously.

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[3]Jimmy Carnes, "Weight Training for Track," Scholastic Coach, 30:34, February, 1961.

[4]Alvin Roy, Strength Program "In and Out" of Season (San Diego: Sid Gillman-Alvin Roy Publishing Co., 1964), p. 8.

A related problem investigated was concerned with the attempt to determine if the extra time spent exercising each leg individually would reap greater benefits than the more economical method of exercising both legs at the same time. In addition to leg strength, leg power and sprinting speed were also measured.

Hypotheses

The use of a select weight training program to exercise each leg individually does not increase leg strength significantly over an identical weight training program exercising both legs simultaneously. In addition, there is no significant difference in the increase in leg power in sprinting speed between the two training programs.

Within groups, both training methods employed does significantly increase the parameters tested.

Delimitations and Limitations

1. This study was limited to twenty-two members of a basic physical education class in weight training at South Dakota State University.

2. The subjects were not on selected diets, nor were they directed to maintain specific sleeping habits.

3. The subjects were allowed to participate in intramurals.

4. The subjects were asked not to partake in any running programs on their own.

5. The length of the program was limited to 9 weeks, consisting of 32 work periods.

Definition of Terms

1. Weight training. The use of weights to increase resistance to the muscle as it moves through a range of motion.

2. Load. The actual poundage that is being lifted during each complete movement of a weight training exercise.

3. Overload. An exercise or load that is above or beyond that to which the body is normally accustomed.[5]

4. Progressive resistance. Gradually increasing the work load as certain levels of fitness are attained.

5. Repetition. The performance of a single exercise from the start through its full range of movement and back again to the starting point.[6]

6. Set. The completion of several repetitions through their full range of motion all during one time sequence.

7. Isotonic contraction. A contraction in which a muscle shortens against a load, resulting in movement and the performance of work.[7]

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[5]Robert Sorani, Circuit Training (Dubuque: Wm. C. Brown Co., 1966), p. 66.

[6]Ibid.

[7]Lawrence E. Morehouse and Augustus T. Miller, Physiology of Exercise (3rd ed. St. Louis: C.V. Mosby Company, 1959), p. 325.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

The review of related literature was limited to research concerning strength, sprinting speed, power, and the use of resistance exercises.

Literature on Strength

Morehouse and Miller define strength as "the ability to exert tension against resistance."[1] This ability relies on the contractile power of muscle tissue. Their study indicates that training plays an important role in the contractile power of a muscle. The overload principle is of more value to strength gains than is the total amount of work. The authors observe that, "only when a muscle is overloaded does it respond by undergoing hypertrophy."[2] However, the authors note that sizeable gains in the amount of weight that can be lifted during the first two or three weeks of training seem to be the result of learning and the acquisition of skill rather than actual increases in strength.[3]

Sorani states that there is a relationship between the size of a muscle and the strength of that muscle. The strength is proportionate

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[1]Lawrence E. Morehouse and Augustus T. Miller, Jr., Physiology of Exercise (5th ed. St. Louis: C.V. Mosby Company, 1967), p. 50.

[2]Ibid., p. 55.

[3]Ibid., pp. 50-59.

to the cross-sectional area of the muscles. Essential to the development of strength is the overload principle. Sorani also relates that "as the progressive overload is applied, the smaller fibers grow in size, often equalling the thickness of the largest."[4] The overload principle can be established by increasing the load, the number of repetitions, speed of contraction, length of time a position is held, or any combination of these.[5]

The amount of force exerted is partly dependent upon the strength of the muscles exerting the force and, because strength of the muscle is dependent upon the cross-sectional area of the muscle, it follows that building muscles is essential to top performance when either optimum or maximum force is desired.[6]

According to Murray and Karpovich there is no question that weight training is beneficial to the development of strength. Training for strength involves an increase in the size of the muscle. Individual differences in development of strength are apparently due partially to heredity; however, the type and intensity of training can be controlled and adjusted so that the individual can experience a substantial strength gain.[7]

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[4]Robert Sorani, Circuit Training (Dubuque, Iowa: Wm. C. Brown Company Publishers, 1966), p. 13.

[5]Ibid., pp. 1-17.

[6]John W. Bunn, Scientific Principles of Coaching (New York: Prentice-Hall, Inc., 1955), p. 85.

[7]Jim Murray and Peter V. Karpovich, Weight Training in Athletics (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1956), pp. 34-44.

In relation to athletics in general and football specifically, Biggs argues that one of the basic requirements for participation is strength. Biggs feels that too many coaches overlook strength and tend to concentrate on the development of skills. Strength can be acquired through a good program of conditioning. In addition to strength a conditioning program can result in a general feeling of well being and self confidence that is very essential to football.[8]

Competitive weight-lifters train with loads that seldom permit more than five repetitions per set, using maximum exertion. Most competitive lifters will use a load from one repetition maximum to five repetitions maximum for at least three sets to as high as ten sets.[9]

Capen's findings indicate that a 1 execution maximum (E.M.) x 3 program was superior to an 8-15 E.M. x 1 program. The study also indicated that a 5 E.M. x 3 program was superior to the 8-15 E.M. x 1 program, and superior to the 8-15 E.M. x 1 in conjunction with the 5 E.M. x 1 program for the development of muscular strength. The 5 E.M. x 3 program was more effective in developing muscular strength when used 3 days a week as compared to 5 days a week.[10]

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[8]Ernest R. Biggs, Jr., Conditioning for Football (Dubuque, Iowa: Wm. C. Brown Company Publishers, 1968), pp. 1-5.

[9]Jim Murray and Peter V. Karpovich, Weight Training in Athletics (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1956), pp. 170-173.

[10]Edward K. Capen, "A Study of Four Programs of Heavy Resistance Exercises for the Development of Muscular Strength" (unpublished Doctoral thesis, University of Iowa, Iowa City, 1954), pp. 1-31.

Berger and Hardage conducted a study on the effects of training with maximum or near maximum loads per repetition as opposed to training with sub-maximum loads. The results of the 8 week program showed that the weight training program employing maximum or near maximum loads for each of ten repetitions are more effective in increasing strength than a program that involved ten repetitions with submaximal loads.[11]

Brown and Riley found that through a progressive resistance program employing only the heel raise on a two-inch board, they could increase the leg strength of their subjects beyond the .01 level of confidence. The tests they employed were the Sargent Jump, Leg Lift Strength Test, and the Ankle Plantar Flexion Strength Test. The writers also emphasized that a training program short in duration seemed to be better than one of longer duration.[12]

Bates found that both isotonic and isometric training increased strength, speed of movement, reaction time and endurance. Bates utilized three training positions for the supine press; the beginning of the movement, mid-position, and near full extension. The author divided his subjects into six groups with three groups assigned to static exercises, and each group utilizing one of three positions.

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[11] Richard A. Berger and Billy Hardage, "Effect of Maximum Loads for Each of Ten Repetitions on Strength Improvement," Research Quarterly, 38:715-718, December, 1967.

[12] Robert S. Brown and Douglas R. Riley, "The Effect of Weight Training on Leg Strength and the Vertical Jump" (unpublished Master's thesis, Springfield College, Springfield, Mass., 1957), pp. 1-48.

"There was no interaction present between the types of training and the positions of exercise in any of the qualities tested."[13]

deVries states that isometric and isotonic methods have shown to bring about significant strength gains in short periods of time, but in investigations in which direct comparisons have been made, the differences favor the isotonic method.[14]

Literature on Power

Some coaches and investigators feel that weight training's greatest contribution to success in football is in increasing one's power.[15] To develop power it is necessary to complete fast, explosive movements against resistance.[16]

Mitchell employed three groups in his study: the first group used the 8-6-4 power training method; the second group used the seven second method; and the third group followed the modified Hanson circuit-training method. The results showed that there was an increase in strength and weight; however, explosive power did not increase to a significant

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[13]James D. Bates, "The Effects of Static and Dynamic Strength Training and Position of Exercise on the Acquisition of Strength, Speed of Movement, Reaction Time, and Endurance" (unpublished Master's thesis, Louisiana State University, Baton Rouge, 1967), pp. 1-77.

[14]Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics (Dubuque: Wm. C. Brown Company Publishers, 1966), p. 307.

[15]Benjamin H. Massey and others, The Kinesiology of Weight Lifting (Dubuque: Wm. C. Brown Company, 1959), p. 58.

[16]Fred Wilt, Run Run Run (Los Altos: Track and Field News, Inc., 1964), p. 262.

degree. The study also showed that the 8-6-4 power training method increased bench press strength significantly more than did the modified Hanson training program.[17]

Through his study Hofmann found that there was no significant increase in explosive power by the weight training group over the group that participated in basketball. However, both groups did increase their explosive power as tested by the jump and reach and as determined by the standing high jump over the initial test.[18]

Johnson and Bierly compared the effects of a specific overload training program, a traditional weight training program, and a combination of both of these on vertical jump scores. As a result of this study the authors found that all three methods improved the vertical jump scores. Although all training methods improved the mean scores, there was no statistical significant difference between the final means.[19]

McClement studied the relationship of power to the strength of leg and thigh muscles. He found significant correlations of .52

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[17]Anthony B. Mitchell, "Effects of Off-Season Weight Training Programs on Development of Strength and Explosive Power of Football Players" (unpublished Master's thesis, South Dakota State University, Brookings, 1970), pp. 1-45.

[18]James A. Hofmann, "A Comparison of the Effect of Two Programs of Weight Training on Explosive Force" (unpublished Master's thesis, South Dakota State University, Brookings, 1959), pp. 1-50.

[19]Perry B. Johnson and Russell Bierly, "Effect of Specific Overload Jumping on Vertical Jump Scores" (Published Research University of Toledo, 1961), cited by College Physical Education Association, December, 1961, pp. 74-79.

between power scores and flexion strength and .65 between power scores and extension strength for the entire experimental group. Eighty-six men (college) were randomly assigned to each of four training groups: the flexor program, the extensor program, the flexor-extensor program, and the control group. The first three of the four groups performed specific exercises designed to develop either flexor or extensor muscles or both. The control group participated in a basic physical education class. A combination of isometrics, weight training, and calisthenics was employed in the four programs. The results of the program showed that all groups gained significantly in extension strength, flexion strength, and power; but, non-significant correlations were obtained between gain scores for these same measurements of strength and power. The investigator concluded that strength is related to power.[20]

Literature Related to Speed

It is felt by many investigators and coaches that speed can be increased by an increase in strength.[21] However, strength and speed are not necessarily directly proportional to each other.[22] This phenomenon

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[20]Lawrence E. McClement, "Power Relative to Strength of Leg and Thigh Muscles," Research Quarterly, 27:71-78, March, 1966.

[21]Samuel Homola, "Specificity in Muscle Building, Part I," Scholastic Coach, 35:28, November, 1965.

[22]Arthur H. Steinhouse, "The Science of Educating the Body," The Journal of Health and Physical Education, 8:348, June, 1937.

is due to the fact that some strength is used to overcome the internal resistance to change in the muscle.[23]

Morehouse and Cooper describe factors in speed of running as follows:

> The lever arrangements of the feet and legs are limiting factors in running performance. Long resistance arms and short effort arms powered by strong muscles are an advantage in speed running.[24]

Zorbas and Karpovich studied the effect weight training has upon the speed of rotary movements of the arm. A special device was made to record the speed of movement. This device automatically registered to the nearest hundredth of a second the time twenty-four complete rotary movements had been completed. Those subjects tested were weight lifters, non-weight lifters, men from Springfield College, and men from a liberal arts college. To minimize fatigue and learning, two tests of twenty-four complete revolutions was used. The results showed that the weight lifters were faster than the non-lifters. This result was significant at the .01 level of confidence. The weight lifters were .29 seconds faster than the liberal arts college group, this difference was significant at the .01 level. The lifters were only .06 seconds faster than the Springfield College group; however, this was significant at the .05 level of confidence.[25]

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[23] Ibid.

[24] Lawrence Morehouse and John Cooper, Kinesiology (St. Louis: The C.V. Mosby Company, 1950), p. 16.

[25] William S. Zorbas and Peter V. Karpovich, "The Effect of Weight Lifting Upon the Speed of Muscular Contractions," Research Quarterly, 22:145-148, May, 1951.

By using two groups, each group employing a different amount of weight, Endres studied the effects of weight training on the speed of elbow flexion and extension. The study indicated that weight training will increase the speed of elbow flexion and extension as indicated by the number of contraction cycles completed within a ten second period of time. In addition to the gain in speed of movement, there was also an increase in strength. The writer also indicated that the amount of increase of both speed and strength was not materially affected by the use of a heavy or light weight as long as the exercises were conducted at maximum speeds.[26]

Although these studies indicate that an increase in strength will increase the speed of movement, Karpovich and Sinning feel that it is much more difficult to increase the speed of movement for "natural" movements such as running. They indicate that developing an increase in speed of movement for specific "skills" is relatively easy.[27]

Clausen stated that tests have shown that assets such as speed and agility are increased by as much as 20 per cent in 4 months of weight training. This is especially true when stretching exercises are performed before and after each weight training period.[28]

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[26]John Paul Endres, "The Effect of Weight Training Exercise Upon the Speed of Muscular Movement" (unpublished Master's thesis, University of Wisconsin, Madison, 1953), p. 1-32.

[27]Peter V. Karpovich and Wayne E. Sinning, Physiology of Muscular Activity (Philadelphia: W. B. Saunders Company, 1971), p. 28.

[28]Dick Clausen, "Weight Training for Football Players," Athletic Journal, 36:52, February, 1956.

Sweeting used three types of training methods designed to improve speed. The methods used were running, weight training, and a combination of running and weight training. In addition to the three groups he included a control group which participated in a physical education class. The study indicated that the running group, which consisted of timed laps and interval sprints along with practiced starts, was significantly faster than either the weight-training group and the control group at the .01 level of confidence. However, there was no significant difference found between the running group and the weight-training-and-running group at the .01 level. All three methods of training produced a significant improvement.[29]

Capen feels that coaches are concerned that weight training will produce muscle tightness and will create a decrease in speed. He completed a study that involved a group that participated in a strenuous conditioning program. The results of this experiment indicated that the probability of a relationship between weight training and muscle tightness and a decrease of speed of muscular contraction does not exist. The study also indicated that both groups increased their body weight. There was an increase in muscular strength by the group who participated in weight training exercises.[30]

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[29]Roger L. Sweeting, "Effects of Various Running and Weight Training Programs on Sprinting Speed" (unpublished Master's thesis, Pennsylvania State University, University Park, September, 1963), pp. 1-40.

[30]Edward K. Capen, "The Effect of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, 21:83-93, May, 1950.

Dintiman attempted to determine if a flexibility program, a weight training program and a program of a combination of the two would effect running speed when used as supplementary training programs to the conventional method of training sprinters. The author divided his subjects into three experimental groups and two control groups. The experimental groups were: Group A employed sprinting and flexibility training; Group B completed sprinting and weight training; Group C employed sprinting, flexibility and weight training programs. The control groups consisted of a sprint training group and an inactive group. Groups A and C performed static flexibility exercises with their sprints. Maximum flexion and extension were stressed. Groups B and C employed weight training designed to increase leg strength along with their sprint training. The weight training exercises were chosen for their effects upon the major muscle groups involved in running action. All subjects were tested on the 50-yard dash for running speed, the Cureton Flexibility Test, and on the leg dynomometer (belt method) for leg strength. The results of this study showed that both weight training and flexibility training, as supplements to sprint training, increased running speed significantly more than an unsupplemented sprint training program.[31]

Helixon found in his study of first year high school track performers that the use of a progressively heavy resistance program did not produce a significant effect on the experimental groups performance

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[31]George Dintiman, "Effect of Various Training Programs on Running Speed," Research Quarterly, 35:456, May, 1964.

in running or jumping over the performance of the control group. However, there was an indication that a pattern of decreasing performance levels was stabilized in the experimental group, whereas, this trend pattern in the control group was maintained.[32]

Meisel found that weight training decreased speed as measured by the 10 yard sprint. By testing three standard weight training classes on strength and the 10 yard sprint, and then administering 6 weeks of training, the author found that there was a definite increase in strength. However, there was a loss of speed as compared to the initial test.[33]

Summary of Related Literature

The literature relating to strength and power indicates agreement that resistance exercises will increase strength and power. However, researchers are still uncertain as to what method of training will increase strength and power most efficiently and economically.

Regarding speed of movement and running speed, very little research has been completed in this area. Those studies reviewed tend to disagree as to whether or not weight training and an increase

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[32]Patrick J. Helixon, "The Effects of Progressive Heavy Resistance Exercises Using Near-Maximum Weights on the Running and Jumping Ability of First Year High School Track Performers" (unpublished Master's thesis, University of Wisconsin, Madison, 1961), pp. 1-61.

[33]Steven G. Meisel, "The Effect of a Weight Training Program on the Speed of Running" (unpublished Master's thesis, Pennsylvania State University, University Park, 1957), pp. 1-40.

in strength will also increase speed.[34,35] However, more research is being completed in this area and the present trend seems to be toward the existence of a correlation between increase in strength and an increase in speed.[36,37]

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[34] Meisel, loc. cit.

[35] Zorbas and Karpovich, loc. cit.

[36] Dintiman, loc. cit.

[37] John W. Masley, Ara Hairabedian, and Donald N. Donaldson, "Weight Training in Relation to Strength, Speed, and Coordination," Research Quarterly, 24:308-315, October, 1953.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to find what effects a select weight training program consisting of exercises for each leg individually would have on leg strength, leg power, and sprinting speed as compared to the same program exercising both legs simultaneously.

Source of Data

Twenty-two students enrolled in weight training classes in the basic physical education program at South Dakota State University were the subjects for this study. No subject was participating in any type of athletics during the study. The characteristics of the subjects are listed in Table I.

Organization of the Study

Prior to the start of the training program the subjects were oriented to the study and were given an opportunity to employ the training methods and perform the exercises that would be used during the program. These periods were also used to reduce any learning effects. Morehouse and Miller feel that many gains in strength that are evident in the early stages of weight training are in actuality not strength gains, but merely a learning process that takes place.[1] The subjects were also familiarized with the correct testing procedures.

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[1] Lawrence E. Morehouse and Augustus T. Miller Jr., Physiology of Exercise (5th ed. St. Louis: C.V. Mosby Company, 1967), pp. 50-59.

TABLE I

SUBJECT CHARACTERISTICS

Subject	Group*	Age	Height	Weight
D.B.	B	18	5'8"	129
T.B.	A	21	5'8"	147
B.C.	B	19	5'9"	169
D.D.	A	21	5'11"	170
R.E.	A	19	5'9"	175
R.H.	B	18	6'2"	175
T.H.	A	18	5'9"	187
R.J.	B	18	5'11"	166
S.J.	B	18	6'1"	150
R.K.	B	19	5'11"	176
B.K.	A	18	5'9"	144
D.M.	B	18	5'10"	147
D.S.	A	18	5'10"	147
L.S.	A	18	6'	168
S.S.	B	18	6'	198
S.T.	B	18	6'1"	190
M.V.	B	20	5'11"	166
R.W.	A	19	5'11"	175
J.WI.	A	18	5'6"	150
J.W.	A	19	5'6"	138
T.W.	A	19	5'10"	143
R.Y.	B	18	5'11"	146

* Group A refers to the group that exercised both legs together.

Group B refers to the group that exercised one leg at a time.

For ease in administering the treatments and for group formation, twenty-two subjects were equated in pairs on the total scores recorded on all measures taken for the determining of leg strength. The eleven pairs which were approximately equal in leg strength were then randomly divided into two groups, with one of each pair in opposite groups. The means of the two groups were taken and were found to be approximately equal in leg strength. The two groups were then randomly assigned the treatments to be administered. Group A was designated as the group to exercise both legs at the same time, while Group B exercised the legs separately. Both groups were administered the following exercises: leg extensions, toe raises and the leg press. All exercises except the toe raises were performed on the Universal Gym. The toe raises were performed in the power racks using the standard Olympic Barbell. In exercising the legs both groups employed the progressive overload principle.

The training program covered a period of approximately 9 weeks, beginning February 2, 1972, and ending April 7, 1972. Thirty-two training sessions were completed in that perid of time. The subjects met every Monday, Wednesday, and Friday.

The initial testing on the parameters began on Wednesday, February 2, 1972, the beginning of the spring semester. The final test period began on Monday, April 10, 1972, 10 weeks after the initial test.

Administration of the Treatment

Group A and B training method. All progressive resistance exercises were identical for both groups except for Group B which exercised each leg separately. The training program employed consisted of leg presses, knee extensions and ankle plantar flexion exercises. Three sets of training bouts for each exercise with each set being five to eight repetitions maximum were administered. The initial poundage used for each exercise was determined by establishing the subjects' maximum lift. The subjects then performed the repetitions with not more than 40 pounds less than the established lift.[2] Each repetition was performed explosively. When a subject was able to achieve eight repetitions for each set, he was then moved up to the next highest weight. The subjects in both groups were verbally encouraged to complete each repetition and set.

Collection of the Data

In order to provide athletes and coaches with objective and practical knowledge about off-season training programs and their relation to leg strength, leg power, and sprinting speed the investigation called for the employment of testing procedures for these categories. The pre and post test procedure was administered and data were organized in order to apply the t test for independent means to determine significance. The testing procedure for all subjects involved

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[2]John Gregory, "Muscle Power" (unpublished document, South Dakota State University, Brookings, 1971), pp. 1-3.

measuring both the right and left leg for each of the strength tests administered. The following sections indicate the methods used to measure the variables.

Leg strength. Strength is a very important factor in all activity since it "takes a certain amount of it to be agile, to have power, and to run fast."[3] To determine leg strength data were collected on knee extension, leg press and ankle plantar flexion of the subjects. The investigator chose the above based on information gathered from coaching clinics, trainers and the review of related literature. The administration of strength tests in this study was limited to the use of the Universal Gym and Cable Tensiometer.

Each subject was asked beforehand to experiment with the weights and the techniques involved in all tests. Through this procedure the writer tried to establish maximum or near maximum capacities of each individual for each test and thus eliminate undue fatigue during the actual testing process.

Measurements of knee extension strength of each leg were taken on the Universal Gym. The subjects were asked to sit on the extension-flexion station of the Universal Gym and raise the weight so that the lower leg was completely extended and parallel to the ground. The participants were asked not to rock forward or backward in order

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[3]Harold M. Barrow and Rosemary McGee, "Strength," A Practical Approach to Measurement in Physical Education (Philadelphia: Lea and Febiger, 1967), p. 115.

that each measurement would be valid. The best of three trials was taken and data were recorded in pounds lifted.

Measurements of leg press strength were taken on the leg press station with backs braced against the chair, and their buttocks flat upon the seat of the chair. The investigator emphasized to the subjects not to raise up in the seat in order to get extra leverage. The best of three trials was recorded in pounds pressed.

Ankle plantar flexion was measured with the cable tensiometer with the subjects supine on the testing table. The objectivity coefficient for this test of strength is 0.93 as indicated by Clarke.[4] The subjects were given time to get acquainted with the tensiometer and its use. Two reliable assistants were used to steady the subject being tested. The subjects were asked to lie on the bench face up with their hands at their sides. The investigator was careful to measure the angle of the ankle joint (90°) and the exact position of the stirrup strap for each individual. The subjects were asked to plantar-flex their feet without a jerking motion. Each participant was given two trials with each leg and the average of the two trials was recorded for data purposes. The pounds of pressure exerted were measured to the nearest half pound.

Leg power. One of the most commonly used methods for determining "explosive" power is the Sargent Jump. It is primarily

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[4] H. Harrison Clarke, "Ankle Plantar Flexion," Cable-Tension Strength Tests (Springfield, Mass.: Stuart E. Murphy, 1953), p. 30.

the measure of a person's ability to develop power in relation to his own body weight.[5]

To administer this test a graduated scale marked off in feet and inches on a wall was employed. The "chalk jump" method was used in this test with each participant receiving three trials, the best of which, was recorded to the nearest inch. This method required the subject to stand flat-footed and reach as high as possible without going to the toes. This height was recorded by the tester. The subject then "chalked" the finger tips and jumped as high as possible, touching the scale with the chalked fingers at the height of the jump. The subject was not allowed to take a run before jumping. The distance between the height reached and the height jumped was recorded to the nearest inch.

All subjects were given a chance to practice the jump using the correct techniques. Van Dalen found that using this procedure reliability coefficients have been reported at .86 and .96.[6]

Sprinting speed. To evaluate sprinting speed the 40 yard dash was used. Coaches accept this distance to check speed because runs during the course of many athletic contests average about 40 yards.

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[5]H. Harrison Clarke, Application of Measurement to Health and Physical Education (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1959), pp. 304-305.

[6]D.B. Van Dalen, "New Studies in the Sargent Jump," Research Quarterly, Vol. XI, No. 2, (Mary, 1940), p. 112 cited by H. Harrison Clarke, "The Sargent Vertical Jump," Application of Measurement to Health and Physical Education, e.d. E.D. Mitchell, (Englewood Cliffs: Prentice-Hall, Inc., 1968), pp. 304-305.

For example, in football most punts, kick-offs, long runs and passes are rarely longer than 40 yards.[7]

A 40 yard distance was marked off on the gymnasium floor. To prevent injuries enough space was provided at the end of the 40 yards to allow ample space for braking.

As testing began during the winter months, the area for testing sprinting speed was limited to the use of the gymnasium. The subjects were divided into pairs and were run together in order to complete all testing. Such competition also served as a stimulant to work at maximum capacity. Two stop watches were applied to each subject. All subjects were allowed two trials during each testing period, and the average time was recorded to the nearest tenth of a second.

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[7]Paul Bryant, Building a Championship Football Team (Englewood Cliffs: Prentice-Hall, Inc., 1968), pp. 114-115.

CHAPTER IV

ANALYSIS OF THE DATA

Organization of the Data

The data on the selected dependent variables were organized in such a manner so as to allow statistical comparisons between exercising one leg at a time versus exercising the two legs simultaneously. The subjects were tested on the eleven dependent variables before (Test I) and after (Test II) the 9 week conditioning program. Group means are shown in Table II. The raw data on all variables for all subjects are found in appendices A, B, and C.

A t ratio was first computed to determine the within group changes for each variable in the two groups from Test I to Test II. Then a t ratio was computed comparing the mean changes from Test I to Test II in each of the independent variables between the groups. The .05 level of confidence was the minimum level needed in order for a difference to be considered significant.

Analysis of the Data

Table III contains the comparison of the within groups changes for the eleven dependent variables from Test I to Test II in Group A. Group A exercised both legs simultaneously. Ten of the eleven variables showed a significant increase from Test I to Test II. Only the 40 yard dash did not show a significant increase in speed, however, it did approach significance as indicated by a t ratio of 2.00 as compared to the required t of 2.23.

TABLE II

GROUP PERFORMANCE MEANS ON THE SELECTED VARIABLES FOR TEST I AND II

Variable	Group A*		Group B*	
	Test I	Test II	Test I	Test II
Right Leg Press (lbs)	220.00	260.00	201.81	285.45
Left Leg Press (lbs)	216.36	256.36	200.00	272.72
Total Leg Press (lbs)	436.36	516.36	401.81	558.18
Right Leg Extension (lbs)	80.00	92.72	82.72	100.45
Left Leg Extension (lbs)	75.45	89.09	80.90	98.18
Total Leg Extension (lbs)	155.45	181.81	163.63	198.63
Right Plantar Flexion (lbs)	263.78	303.93	251.96	323.10
Left Plantar Flexion (lbs)	240.45	287.72	228.18	302.34
Total Plantar Flexion (lbs)	497.72	591.66	480.15	625.45
40 Yard Dash (seconds)	5.49	5.42	5.58	5.53
Power Jump (inches)	22.03	23.43	21.10	22.91

*Group A refers to the group that exercised both legs simultaneous.

*Group B refers to the group that exercised each leg individually.

TABLE III

DIFFERENCES WITHIN GROUP A FROM PRE TO POST TEST
IN THE SELECTED VARIABLES

Variable	Pre Test	Post Test	$\bar{X}$ Diff	SE_D	t*
Right Leg Press	220.00	260.00	40.00	7.62	5.25
Left Leg Press	216.36	256.36	40.00	6.60	6.06
Total Leg Press	436.36	516.36	80.00	13.74	5.82
Right Leg Extension	80.00	92.72	12.72	2.46	5.17
Left Leg Extension	75.45	89.09	13.64	2.62	5.21
Total Leg Extension	155.45	181.81	26.36	4.37	6.03
Right Plantar Flexion	263.78	303.93	40.15	5.88	6.83
Left Plantar Flexion	240.45	287.72	47.27	10.48	4.51
Total Plantar Flexion	497.72	591.66	93.94	15.03	6.25
40 Yard Dash	5.49	5.42	-0.07	.035	-2.00
Power Jump	22.03	23.43	1.4	.43	3.25

$t_{.05}(10) = 2.23$

* t .05

Table IV contains the comparison of the within groups changes for the eleven dependent variables from Test I to Test II in Group B. Group B exercised each leg individually. Ten of the eleven variables for this group also showed a significant increase from Test I to Test II. Once again, only the 40 yard dash did not show a significant increase in speed but improvement was noted.

Table V contains the $\underline{t}$ ratios comparing the changes in the eleven independent variables (between the two groups) from Test I to Test II. The results of the $\underline{t}$ ratio statistics procedure produced only significant differences at the .05 level of confidence in the right leg press, left leg press, and total leg press. In all three cases the significant differences favored Group B. Although no significant differences were found for any of the other parameters, mean scores did indicate general increases by Group B over Group A from the initial test to the final test in all leg extension tests and all plantar flexion tests. There was a slightly greater gain experienced by Group B over Group A in the power jump.

Discussion of Results

An overall summary of the results indicated that significant improvement will occur whether or not the single leg method of exercising or the method of exercising both legs simultaneously is used. This is supported by the fact that all of the strength and power parameters analyzed showed significant increases within each group. The improvement which occurred within each group was expected. This improvement occurred because both groups followed the progressive

TABLE IV

DIFFERENCES WITHIN GROUP B FROM PRE TO POST TEST IN THE SELECTED VARIABLES

Variable	Pre Test	Post Test	$\bar{X}$ Diff	SE_D	t*
Right Leg Press	201.81	285.45	83.64	8.00	10.45
Left Leg Press	200.00	272.72	72.72	9.81	7.41
Total Leg Press	401.81	558.18	156.37	16.79	9.31
Right Leg Extension	82.72	100.45	17.73	3.24	5.45
Left Leg Extension	80.90	98.18	17.28	3.04	5.68
Total Leg Extension	163.63	198.63	35.00	5.30	6.60
Right Plantar Flexion	251.96	323.10	71.14	16.60	4.28
Left Plantar Flexion	228.18	302.34	74.16	11.29	6.57
Total Plantar Flexion	480.15	625.45	145.30	27.73	5.24
40 Yard Dash	5.58	5.53	-.05	.033	-1.52
Power Jump	21.10	22.91	1.81	.468	3.87

* $t_{.05}(10) = 2.23$

TABLE V

DIFFERENCES BETWEEN MEANS FOR WEIGHT TRAINING GROUPS IN ALL PARAMETERS FROM PRE TO POST TESTS

Variable	Group A Change	Group B Change	$\bar{X}$ Diff	$SE_{\bar{d}}$	t*
Right Leg Press	440.00	920.00	43.69	11.059	3.95
Left Leg Press	440.00	700.00	34.55	10.648	3.24
Total Leg Press	880.00	1720.00	76.36	21.711	3.52
Right Leg Extension	140.00	195.00	5.00	4.085	1.22
Left Leg Extension	150.00	190.00	3.63	4.019	.90
Total Leg Extension	290.00	385.00	8.64	6.878	1.26
Right Plantar Flexion	441.65	782.48	30.98	18.466	1.68
Left Plantar Flexion	626.66	815.80	17.20	14.712	1.17
Total Plantar Flexion	1068.31	1598.28	48.18	30.857	1.56
40 Yard Dash	-.8	-.6	-.018	.063	-.28
Power Jump	17.75	19.75	.181	.782	.23

* $t_{.05}(20) = 2.09$, $t_{.01}(20) = 2.89$.

overload principle in their respective conditioning programs. Research indicates that training with maximum or near maximum loads will result in significant increases in strength and power.[3,4,5,6,7]

Sprinting speed times did not significantly increase in either of the two groups. These results are contrary to the conclusions of the studies completed by Endres, Zorbas and Karpovich.[8,9] Such results obtained in this study may be partially due to lack of stretching and flexibility exercises before and after each weight training period. Clausen indicated that speed and agility can be increased as much as 20 per cent in 4 months if flexibility exercises were performed in conjunction with the weight training.[10] Steinhouse stated that speed

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[3]Lawrence E. Morehouse and Augustus T. Miller, Jr., Physiology of Exercise (St. Louis: C.V. Mosby Company, 1967), p. 40.

[4]Jim Murray and Peter V. Karpovich, Weight Training in Athletics (Englewood Cliffs: Prentice-Hall, Inc., 1956), pp. 170-173.

[5]Richard A. Berger and Billy Hardage, "Effect of Maximum Loads for Each of Ten Repetitions on Strength Improvement," Research Quarterly, 38:715-718, December, 1967.

[6]Edward K. Capen, "A Study of Four Programs of Heavy Resistance Exercises for the Development of Muscular Strength" (unpublished Doctoral thesis, University of Iowa, Iowa City, 1954), pp. 1-31.

[7]Lawrence E. McClement, "Power Relative to Strength of Leg and Thigh Muscles," Research Quarterly, 27:71-78, March, 1966.

[8]William S. Zorbas and Peter V. Karpovich, "The Effect of Weight Lifting Upon the Speed of Muscular Contractions," Research Quarterly, 22:145-148, May, 1951.

[9]John Paul Endres, "The Effect of Weight Training Exercise upon the Speed of Muscular Movement" (unpublished Master's thesis, University of Wisconsin, Madison, 1953), pp. 1-32.

[10]Dick Clausen, "Weight Training for Football Players," Athletic Journal, 36:52, February, 1956.

could be increased through a gain in strength. However, increases in speed and strength are not necessarily directly proportional to each other. In other words, even though sizable gains in strength are made, the increase in speed may not be equal to the gain in strength.[11] On the other hand, Karpovich and Sinning concluded that it is difficult to increase speed for "natural" movements such as running.[12]

When comparing programs exercising one leg versus exercising both legs simultaneously, there is some indication that the one leg exercise program is the better for the development of leg strength. For example, Group B was significantly better than Group A in three variables. In the remaining six strength variables, however, the improvement favored Group B in all cases even though the results were not significant. The fact that the other results were not significant may be due to the variability of the subjects within the groups. Although the groups were equated at the onset of the program, there was considerable variance between individuals within each group. In various instances a subject may have added 100 pounds in performing the leg press, whereas another member of his group only added 10 pounds. This inconsistency may be the reason for the insignificance in the remaining six strength parameters.

There are some possible explanations as to why Group B increased to a greater extent in leg press strength over Group A. Homola suggests

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[11]Arthur H. Steinhouse, "The Science of Educating the Body," The Journal of Health and Physical Education, 8:348, June, 1937.

[12]Peter V. Karpovich and Wayne E. Sinning, Physiology of Muscular Activity (7th ed. Philadelphia: W.B. Saunders Company, 1971), p. 28.

that weak areas of the body tend to remain weak because of compensatory habit patterns that prevent these areas from carrying their share of the load.[13] Group A exercised both legs, thus concentrating on both legs. In this method the weak muscles may have been compensated for by the stronger ones. In other words, in exercising both legs, if the left leg were weaker than the right, the right would compensate for the weakness of the left. In Group B the subjects concentrated on exercising each leg individually, and the weak muscles were not allowed to be compensated for by the strong ones. In concentrating on each leg individually, more muscle fibers were put into use, creating a greater change in strength. Literature supporting the above indicates that concentration in exercise will increase the muscle used in overcoming greater amounts of resistance. Thus, the heavier the resistance, the greater the number of contracting fibers.[14]

The number of muscles involved in each exercise may also account for the significant difference between the groups' improvements in the leg press strength and lack of improvement in plantar flexion and leg extension. In completing the plantar flexion exercise only the gastrocnemius and the soleus muscles are used. During the completion of leg extensions, the quadriceps are concentrated upon without much help from other muscles. However, in completing the leg press, the gastrocnemius, soleus, quadriceps, and the hip extensors are all

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[13] Samuel Homola, Muscle Training for Athletics (West Nyack, New York: Parker Publishing Company, 1969), p. 10.

[14] Ibid., p. 12.

exercised. This combination of muscle groups may create the situation in which leg press strength would significantly increase for one group over another, while the plantar flexion and leg extension strength parameters would not.

Although leg power results showed that each group made significant gains within the group, there was no significant difference between the two groups. This evidence concurs with the findings of other researchers who found that there was no significant increase in explosive power by employing one specific weight training group over another. However, there was an increase in explosive power as tested by the jump and reach test over the initial test.[15,16,17] It should be pointed out that the above studies were based on training programs in which both legs were exercised simultaneously. This study, on the other hand, compared a program in which each leg was exercised separately to a program in which both legs were exercised simultaneously.

Although the mean scores did indicate that there were general increases in leg strength by Group B over Group A, the writer felt that precise recommendations are difficult to make as to which program should be utilized. Because the results showed no significant

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[15] James A. Hofmann, "A Comparison of the Effect of Two Programs of Weight Training on Explosive Force" (unpublished Master's thesis, South Dakota State University, Brookings, 1959), pp. 1-50.

[16] Perry B. Johnson and Russell Bierly, "Effect of Specific Overload Jumping on Vertical Jump Scores" (Published Research, University of Toledo, 1961), cited by (College Physical Education Association, December, 1961), pp. 74-79.

[17] McClement, loc. cit.

differences in eight of the parameters tested between the two groups, the writer felt that if time were a factor, the indications were that the method used by Group A would be the program to employ.

On the other hand, the writer felt that the data from Table II, along with significant differences by Group B in three of the strength parameters, indicate that Group B's training method may be of special value to certain individuals. Individuals with leg injuries, contenital deformities, or strength weaknesses in one leg would benefit from the program as employed by Group B. It would also seem that if time were not a crucial element, as in many off-season programs, the results indicate that Group B's training method would be the more beneficial of the two.

On the basis of the results of this study and within the limitations of this study, the following conclusions relative to the stated hypotheses were made:

1. The first null hypothesis stated that the use of a select weight training program to exercise each leg individually does not increase leg strength significantly over an identical weight training program exercising both legs simultaneously. This hypothesis was not totally rejected. That part of this hypothesis concerning leg press strength was rejected. In those parameters which involved leg extension and plantar flexion, the hypothesis was retained.

2. The second null hypothesis stated that there would be no significant difference in the increase in leg power and sprinting speed between the two groups. This hypothesis was retained.

3. The directional hypothesis stated that within groups, the parameters being tested would significantly increase. This hypothesis was accepted for ten of the eleven variables. All parameters dealing with leg strength and power significantly increased within groups as a result of their respective exercise programs. Only the 40 yard dash did not significantly change in either group.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this investigation was to determine what effects a select weight training program consisting of exercises for each leg individually would have on leg strength as compared to the same program exercising both legs simultaneously. In addition, leg power and sprinting speed were also measured.

Twenty-two subjects enrolled in basic physical educational classes of weight training at South Dakota State University were the subjects for this study. All subjects were tested initially on Wednesday, February 2, 1972, with the final test period beginning Monday, April 10, 1972, 10 weeks after the initial test.

Training covered a period of 9 weeks with the subjects meeting on Monday, Wednesday, and Friday for 32 training sessions. The subjects leg strength was measured by the leg press, leg extension, and plantar flexion. Leg power was measured by the vertical jump and sprinting speed was measured by the 40 yard dash.

The two group's training programs consisted of three exercises: the leg press, leg extension, and plantar flexion (toe raises). All exercises were performed on the Universal Gym with the exception of the toe raises which were performed in the power racks using standard Olympic barbells.

Leg press strength was measured to the nearest 20 pounds by the best of three leg presses performed through a full range of motion. Leg extension strength was measured to the nearest 10 pounds by the best of three leg extensions performed through the full range of motion. Plantar flexion strength was measured to the nearest $\frac{1}{2}$ pound by taking the average of two trials utilizing the cable tensiometer as employed by Clarke.[1]

Leg power was measured by the best of three attempts employing the Sargent Jump as described by Clarke.[2] Body weight was measured by weighing the subjects to the nearest pound at the start and the completion of the training period. To evaluate sprinting speed the 40 yard dash was used. The average of two sprints was measured to the nearest 1/10 of a second. Coaches accept this distance to check speed because runs during the course of many athletic contests average approximately 40 yards. For example, in football most punts, kick-offs, long runs and passes are rarely longer than 40 yards.[3]

Data were collected and recorded in such a manner that provided for the differences in strength, power, and speed between the groups

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[1] H. Harrison Clarke, "Ankle Plantar Flexion," Cable-Tension Strength Tests (Springfield, Mass., Stuart E. Murphy, 1953), p. 30.

[2] H. Harrison Clarke, Application of Measurement to Health and Physical Education (Englewood Cliffs, N.J., Prentice-Hall, Inc., 1959), pp. 304-305.

[3] Paul Bryant, Building a Championship Football Team (Englewood Cliffs: Prentice-Hall, Inc., 1968), pp. 111-115.

to be measured. The .05 level of confidence was accepted as the minimal level needed in order for the null hypothesis to be rejected.

Results of the t ratio computed for comparison of group mean changes from Test I to Test II indicated that Group B's training method produced significant increases in right, left, and total leg press strength beyond the .05 level of confidence. However, leg extension and plantar flexion strength as well as leg power and sprinting speed were not significantly improved. The mean scores did indicate that Group B improved more than did Group A in all parameters except the 40 yard dash from Test I to Test II.

Results of the "difference method" computed for comparison of the group's mean changes showed significant changes for both groups in all parameters except the 40 yard dash at the .01 level of confidence. Neither Group A or Group B produced significant results in the 40 yard dash, however, Group A approached significance at the .05 level.

Conclusions:

1. Weight training methods which employ training one leg at a time or both legs simultaneously will significantly improve leg strength and power. However, neither of the weight training methods significantly improved sprinting speed.

2. There is a strong indication that exercising each leg individually is better for the development of leg strength than exercising both legs simultaneously.

Recommendations for Further Study

1. A similar study be conducted involving a longer training period and additional testing.

2. A similar study be conducted with greater emphasis upon running or sprinting speed, and with an additional emphasis on stretching and flexibility exercises at the beginning and end of the weight training exercises.

3. A similar study be completed employing a larger sample.

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APPENDIX

APPENDIX A

TABLE VI

GROUP "A" - RIGHT LEG PRESS (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	200.00	240.00
D.D.	220.00	300.00
R.E.	200.00	240.00
T.H.	260.00	300.00
R.K.	280.00	300.00
D.S.	220.00	260.00
L.S.	280.00	280.00
R.W.	200.00	220.00
J.WI.	240.00	260.00
J.W.	160.00	220.00
T.W.	160.00	240.00
Means	220.00	260.00
SD	40.00	29.54

APPENDIX A

TABLE VII

GROUP "B" - RIGHT LEG PRESS (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	140.00	220.00
B.C.	220.00	320.00
B.H.	180.00	240.00
R.J.	240.00	360.00
S.J.	180.00	240.00
R.K.	260.00	320.00
D.M.	160.00	300.00
S.S.	220.00	280.00
S.T.	200.00	280.00
M.V.	260.00	340.00
R.Y.	160.00	240.00
Means	201.81	285.45
SD	39.50	44.39

APPENDIX A

TABLE VIII

GROUP "A" - LEFT LEG PRESS (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	200.00	240.00
D.D.	220.00	280.00
R.E.	220.00	280.00
T.H.	220.00	280.00
R.K.	280.00	300.00
D.S.	220.00	260.00
L.S.	260.00	260.00
R.W.	180.00	200.00
J.WI.	240.00	260.00
J.W.	180.00	240.00
T.W.	160.00	220.00
Means	216.36	256.36
SD	33.92	28.05

APPENDIX A

TABLE IX

GROUP "B" - LEFT LEG PRESS (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	160.00	220.00
B.C.	220.00	320.00
B.H.	160.00	240.00
R.J.	240.00	340.00
S.J.	180.00	200.00
R.K.	260.00	320.00
D.M.	180.00	300.00
S.S.	220.00	240.00
S.T.	200.00	280.00
M.V.	220.00	320.00
R.Y.	160.00	220.00
Means	200.00	272.72
SD	33.03	47.69

APPENDIX A

TABLE X

GROUP "A" - TOTAL LEG PRESS (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	400.00	480.00
D.D.	440.00	580.00
R.E.	420.00	520.00
T.H.	480.00	580.00
B.K.	560.00	600.00
D.S.	440.00	520.00
L.S.	540.00	540.00
R.W.	380.00	420.00
J.WI.	480.00	520.00
J.W.	340.00	460.00
T.W.	320.00	460.00
Means	436.36	516.36
SD	72.27	54.48

APPENDIX A

TABLE XI

GROUP "B" - TOTAL LEG PRESS (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	300.00	440.00
B.C.	440.00	640.00
B.H.9	340.00	480.00
R.J.	480.00	700.00
S.J.	360.00	440.00
R.K.	520.00	640.00
D.M.	340.00	600.00
S.S.	440.00	520.00
S.T.	400.00	560.00
M.V.	480.00	660.00
R.Y.	320.00	460.00
Means	401.81	558.18
SD	71.07	90.84

APPENDIX A

TABLE XII

GROUP "A" - RIGHT PLANTAR FLEXION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	250.00	280.00
D.D.	230.00	257.50
R.E.	285.00	320.00
T.H.	306.67	346.66
R.K.	280.00	300.00
D.S.	280.00	306.67
L.S.	290.00	346.66
R.W.	255.00	287.50
J.WI.	295.00	363.33
J.W.	210.00	235.00
T.W.	220.00	300.00
Means	263.78	303.93
SD	31.18	37.20

APPENDIX A

TABLE XIII

GROUP "B" - RIGHT PLANTAR FLEXION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	235.00	247.50
B.C.	313.33	396.66
B.H.	260.00	423.33
R.J.	285.00	353.33
S.J.	200.00	273.33
R.K.	163.33	326.66
D.M.	166.66	285.00
S.S.	326.66	346.66
S.T.	306.67	295.00
M.V.	295.00	333.33
R.Y.	220.00	273.33
Means	251.96	323.10
SD	55.99	52.18

APPENDIX A

TABLE XIV

GROUP "A" - LEFT PLANTAR FLEXION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	225.00	240.00
D.D.	205.00	270.00
R.E.	183.33	297.50
T.H.	235.00	300.00
R.K.	260.00	282.50
D.S.	255.00	300.00
L.S.	300.00	380.00
R.W.	245.00	292.50
J.WI.	245.00	333.33
J.W.	220.00	202.50
T.W.	200.00	266.66
Means	240.45	287.72
SD	37.39	44.04

APPENDIX A

TABLE XV

GROUP "B" - LEFT PLANTAR FLEXION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	186.66	237.50
B.C.	245.00	326.66
B.H.	240.00	389.99
R.J.	320.00	396.66
S.J.	235.00	260.00
R.K.	166.66	280.00
D.M.	146.66	245.00
S.S.	280.00	326.66
S.T.	240.00	269.99
M.V.	260.00	316.66
R.Y.	190.00	276.66
Means	228.18	302.34
SD	48.94	51.75

APPENDIX A

TABLE XVI

GROUP "A" - TOTAL PLANTAR FLEXION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	475.00	520.00
D.D.	435.00	527.50
R.E.	468.33	617.50
T.H.	541.67	646.66
B.K.	540.00	582.50
D.S.	535.00	606.67
L.S.	590.00	726.66
R.W.	500.00	580.00
J.WI.	540.00	696.66
J.W.	430.00	437.50
T.W.	420.00	566.66
Means	497.72	591.66
SD	53.39	78.06

APPENDIX A

TABLE XVII

GROUP "B" - TOTAL PLANTAR FLEXION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	421.66	485.00
B.C.	558.33	723.32
B.H.	500.00	813.32
R.J.	605.00	749.99
S.J.	435.00	533.33
R.K.	329.99	606.66
D.M.	313.32	530.00
S.S.	606.66	673.32
S.T.	546.67	564.99
M.V.	555.00	649.99
R.Y.	410.00	549.99
Means	480.15	625.45
SD	99.49	100.14

APPENDIX A

TABLE XVIII

GROUP "A" - RIGHT LEG EXTENSION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	80.00	100.00
D.D.	60.00	90.00
R.E.	70.00	80.00
T.H.	100.00	115.00
R.K.	60.00	75.00
D.S.	80.00	95.00
L.S.	110.00	110.00
R.W.	110.00	125.00
J.WI.	70.00	75.00
J.W.	70.00	75.00
T.W.	70.00	80.00
Means	80.00	92.72
SD	17.58	16.97

APPENDIX A

TABLE XIX

GROUP "B" - RIGHT LEG EXTENSION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	60.00	85.00
B.C.	80.00	95.00
B.H.	80.00	100.00
R.J.	70.00	110.00
S.J.	90.00	95.00
R.K.	90.00	90.00
D.M.	80.00	100.00
S.S.	100.00	110.00
S.T.	90.00	105.00
M.V.	90.00	110.00
R.Y.	80.00	105.00
Means	82.72	100.45
SD	10.52	8.10

APPENDIX A

TABLE XX

GROUP "A" - LEFT LEG EXTENSION (RECORDED IN POUNDS)

Subjects	Pre Test	Post Test
T.B.	80.00	90.00
D.D.	60.00	90.00
R.E.	60.00	80.00
T.H.	100.00	115.00
R.K.	70.00	70.00
D.S.	80.00	90.00
L.S.	100.00	110.00
R.W.	90.00	115.00
J.WI.	70.00	75.00
J.W.	60.00	75.00
T.W.	60.00	70.00
Means	75.45	89.09
SD	14.99	16.48

APPENDIX A

TABLE XXI

GROUP "B" - LEFT LEG EXTENSION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	60.00	80.00
B.C.	80.00	95.00
B.H.	80.00	95.00
R.J.	70.00	110.00
S.J.	80.00	90.00
R.K.	90.00	115.00
D.M.	80.00	95.00
S.S.	90.00	110.00
S.T.	90.00	100.00
M.V.	90.00	90.00
R.Y.	80.00	100.00
Means	80.90	98.18
SD	8.99	9.83

APPENDIX A

TABLE XXII

GROUP "A" - TOTAL LEG EXTENSION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
T.B.	160.00	190.00
D.D.	120.00	180.00
R.E.	130.00	160.00
T.H.	200.00	230.00
B.K.	130.00	145.00
D.S.	160.00	185.00
L.S.	210.00	220.00
R.W.	200.00	240.00
J.WI.	140.00	150.00
J.W.	130.00	150.00
T.W.	130.00	150.00
Means	155.45	181.81
SD	31.73	33.18

APPENDIX A

TABLE XXIII

GROUP "B" - TOTAL LEG EXTENSION (RECORDED IN POUNDS)

Subject	Pre Test	Post Test
D.B.	120.00	165.00
B.C.	160.00	190.00
B.H.	160.00	195.00
R.J.	140.00	220.00
S.J.	170.00	185.00
R.K.	180.00	205.00
D.M.	160.00	195.00
S.S.	190.00	220.00
S.T.	180.00	205.00
M.V.	180.00	200.00
R.Y.	160.00	205.00
Means	163.63	198.63
SD	19.20	14.94

APPENDIX B

TABLE XXIV

GROUP "A" - POWER JUMP (RECORDED IN INCHES)

Subject	Pre Test	Post Test
T.B.	28.875	21.375
D.D.	26.125	27.00
R.E.	20.875	21.125
T.H.	17.25	21.25
R.K.	21.75	21.50
D.S.	25.25	27.625
L.S.	27.50	28.25
R.W.	23.625	22.75
J.WI.	19.50	22.50
J.W.	22.37	23.50
T.W.	17.00	20.875
Means	22.03	23.43
SD	3.284	2.687

APPENDIX B

TABLE XXV

GROUP "B" - POWER JUMP (RECORDED IN INCHES)

Subject	Pre Test	Post Test
D.B.	21.875	21.625
B.C.	18.75	22.125
B.H.	21.625	21.75
R.J.	24.00	26.875
S.J.	20.875	22.625
R.K.	24.50	27.875
D.M.	19.875	21.375
S.S.	23.625	28.75
S.T.	18.50	19.375
M.V.	19.125	21.25
R.Y.	19.25	18.375
Means	21.10	22.91
SD	2.096	3.252

APPENDIX C

TABLE XXVI

GROUP "A" - FORTY YARD DASH (RECORDED IN SECONDS)

Subject	Pre Test	Post Test
T.B.	5.375	5.325
D.D.	5.40	5.30
R.E.	5.45	5.275
T.H.	5.825	5.75
B.K.	5.65	5.70
D.S.	5.10	5.10
L.S.	5.25	5.15
R.W.	5.55	5.525
J.WI.	5.25	5.425
J.W.	5.50	5.40
T.W.	6.05	5.65
Means	5.49	5.42
SD	.257	.205

APPENDIX C

TABLE XXVII

GROUP "B" - FORTY YARD DASH (RECORDED IN SECONDS)

Subject	Pre Test	Post Test
D.B.	5.50	5.325
B.C.	5.80	5.50
B.H.	5.70	5.725
R.J.	5.10	5.00
S.J.	5.75	5.625
R.K.	5.25	5.425
D.M.	5.85	5.75
S.S.	5.275	5.15
S.T.	6.15	6.075
M.V.	5.425	5.60
R.Y.	5.65	5.675
Means	5.58	5.53
SD	.293	.282