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Effects of Two Speeds of Isokinetic Training on Strength, Power & Muscular Endurance

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EFFECTS OF TWO SPEEDS OF ISOKINETIC TRAINING ON STRENGTH, POWER AND MUSCULAR ENDURANCE

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EFFECTS OF TWO SPEEDS OF ISOKINETIC TRAINING
ON STRENGTH, POWER AND MUSCULAR ENDURANCE

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TABLE OF CONTENTS

Chapter Page

TABLES

LIST OF ILLUSTRATIONS

EFFECTS OF TWO SPEEDS OF ISOKINETIC TRAINING ON STRENGTH, POWER AND MUSCULAR ENDURANCE

Kunle Adeyanju July 1979 92 pages

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The purpose of this investigation was to determine the effects of two speeds of isokinetic training on muscular strength, power and endurance on college females.

The study involved thirty college females. Twenty of the subjects who served in the experimental groups were randomly assigned to one of two groups: fast speed or slow speed group. This was done after matching based on the pretest strength measure. Ten subjects who served as the control group were from a bowling class. This investigation was conducted for seven weeks with a training frequency of three days per week. The experimental treatment was isokinetic training for right and left knee extensions. There were three sets of repetitions; each set lasted twenty seconds with a thirty second rest period between each set. The dependent variables measured were strength, Power I, Power II and muscular endruance for the right and left knee extension.

Analysis of variance was used to determine differences between the groups on pretest measures. A comparison of the pretest and posttest means was made to determine differences

resulting from training. Analysis of covariance was used for the posttest measures with pretest measures as covariates for the eight dependent variables.

Results of statistical analysis indicated that no significant differences existed on the pretest measures between the three groups in the eight variables with the exception of Power I for the right knee and endurance measure for the left knee extension. Posttest analysis revealed significant differences in all the eight dependent variables between the experimental groups and the control group. Also, significant differences existed between the fast speed and the slow speed groups for six of the eight variables. There were no significant differences on the strength measures between the experimental groups.

The isokinetic training method was found to be effective in developing strength, power and muscular endurance. Also, the isokinetic fast speed was found to be a more effective way of bringing about power and muscular endurance development.

CHAPTER I

THE PROBLEM

Introduction

It has been recognized that every individual requires a certain level of muscular strength, power and endurance for the accomplishment of daily engagements. It is also now recognized that a combination of the three abilities mentioned above are extremely important for all activities and are indispensible to successful performance in competitive sports. This being the case, muscular strength, power and endurance training--depending on the requirement of each activity--should be an integral part of the training programs for all athletes.

Muscular strength is the force a muscle or muscle group can exert against a resistance in a single maximum effort. Power is a measure of the ability of a muscle or muscle group to expend force. It is also the exertion of maximum force in one or a series of explosive acts. Muscular endurance, on the other hand, is the ability of a muscle or muscle group to perform prolonged repeated exertion without experiencing fatigue. The amount of resistance involved in endurance activity is not as great as that required for strength or power activities.

Physical educators and coaches have always been interested

in developing training programs that can bring about improvement in the performance of their students and athletes. All athletes need muscular strength, power and endurance of varying degrees depending on the demand of their specific sport or event (22). Awareness of the effects of these three factors in athletic performance has led many investigators to look at the ways these three factors can best be developed.

Heavy resistive exercises are usually employed in increasing functional performance in athletes. The use of weight training has been employed in developing strength. This method utilizes the overload principle in which a muscle or a muscle group is made to work against a resistance greater than normal. This method of training is called Progressive Resistance exercise.

Statement of the Problem

The purpose of the study was to determine the effect of isokinetic training on the development of muscular strength, power and endurance. Another purpose of the study was to determine the effects of two speeds of training on muscular strength, power and endurance.

Significance of the Study

Isokinetic training is an innovation in the development of muscular strength, power and endurance. As such, studies are limited in terms of the best protocol for achieving muscular strength, power and endurance. In this study, it was expected

that the results would show the effect of isokinetic training on muscular strength, power and endurance. It was also expected that the outcome of the study would determine the isokinetic speed that would bring about the largest gain in muscular strength, power and endurance. This information would be of considerable value in the preparation of students and athletes by physical education instructors and coaches.

Hypotheses

The following Null Hypotheses were tested:

1. There will be no significant difference in terms of posttest muscular strength between the three treatment groups after correcting for initial level of strength for the right knee extension.

2. There will be no significant difference in terms of the posttest muscular strength between the three treatment groups after correcting for initial level of strength for the left knee extension.

3. There will be no significant difference in terms of the posttest Power I measure between the three treatment groups after correcting the initial level of Power I for the right knee extension.

4. There will be no significant difference in terms of the posttest Power I measure between the three treatment groups after correcting for initial level of Power I for the left knee extension.

5. There will be no significant difference in terms of the posttest Power II measure between the three treatment groups after correcting for initial level of Power II for the right knee extension.

6. There will be no significant difference in terms of the posttest Power II measure between the three treatment groups after correcting for initial level of Power II for the left knee extension.

7. There will be no significant difference in terms of the posttest muscular endurance between the three treatment groups after correcting for initial level of muscular endurance for the right knee extension.

8. There will be no significant difference in terms of the posttest muscular endurance between the three treatment groups after correcting for initial level of muscular endurance for the left knee extension.

Delimitations

The investigation was conducted for seven weeks. Thirty college age females were used as subjects and were divided into three groups: two experimental and one control. All subjects were right handed. The three groups were tested before and at the termination of the experimental treatments.

The dependent variables obtained were muscular strength, power and endurance. Each subject was tested on muscular strength, power and endurance. Each subject was tested for

strength measure at the limb motion of 30 degrees revolution per second, and for the power and muscular endurance measure, each subject was tested at the limb motion of 180 degrees revolution per second. The isokinetic machine Cybex II was used for the measurement.

Limitations

1. The initial selection of possible subjects for the experimental groups was done randomly, but the final subjects volunteered from the randomly selected group.

2. Subjects for the study were all female; this may limit the generalization of the outcome of the study.

Assumptions

The following assumptions were considered while conducting this study:

1. That the subjects did not participate in any regular exercise program other than the program for the study.

2. That the subjects put forth maximal effort during the tests and the training period.

Definition of Terms Used

1. Accommodating Resistance: The resistance of the exercising device automatically matches the exerciser's immediate and specific muscular capacity at every point in the full range of motion. (13)

2. Cybex II: A dynamic accommodating resistance instrument which provides resistance that matches an exercise force output throughout the range of movement. It has a range of selectable speeds. (46)

3. Full Range of Motion: This is the performance of an exercise in such a manner that each repetition results in movements through the full distance from each outer limit imposed by the limitation of the joints involved or by the exercise description. (22)

4. Isokinetic Exercise (contraction): The contraction in which the tension developed by the muscle while shortening is maximal over the full range of motion. (22)

5. Isokinetic Fast Speed: The isokinetic training in which the speed of training on the Orthotron Isokinetic machine is set at a velocity number 7.

6. Isokinetic Slow Speed: The isokinetic training in which the speed of training on the Orthotron Isokinetic machine is set at velocity number 2½.

7. Isometric Exercise or Contraction: A contraction in which the muscle generates force but there is no observable movement at the joint.

8. Isotonic Exercise or Contraction: A contraction in which the muscle shortens with varying tension while lifting a constant load. It is also referred to as dynamic contraction. (22)

9. Muscular Endurance: The ability of a muscle or muscle group to perform repeated contractions again a light load for

an extended period of time, it is also the ability of a muscle or muscle group to perform prolonged bouts of work without experiencing fatigue or exhaustion. (14)

10. Orthrotron: A system for providing isokinetic resistive exercise to the knees, ankle and shoulder musculature.

11. Muscular Power: The ability to expend a maximum of energy in one or a series of explosive acts. (46)

12. Muscular Strength: The force that a muscle or muscle group can exert against a resistance in one maximum effort. (22)

13. Progressive Resistance Exercise: The method by which the resistance used in training is progressively increased as the body adapts to the training stimulus.

14. Repetition Maximum: The amount of weight that can be lifted through a full range of motion for an indicated number of repetitions before fatiguing.

15. Set: The number of repetitions in a training program that is done consecutively without resting.

16. Weight Training: A progressive resistance exercise used in developing strength and endurance. It usually involves the use of barbells or weight lifting machine.

Summary

Isokinetic exercise is an innovation in the development of muscular strength, power and endurance. There exists a need to know the effects of different speeds of isokinetic training on muscular strength, power and endurance.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

A review of related literature is presented to provide background knowledge of completed research in the areas related to the problem selected for this study. The purpose of this investigation was to determine the effect of isokinetic training at two speeds--slow and fast--on muscular strength, power and endurance. The literature review is organized in the following manner: resistive exercises; isometric and isotonic exercises; isokinetic exercises; resistive exercises and women; and muscular strength, power and endurance.

Resistive Exercises

Resistive exercise provides one of the most effective methods of developing functional performance. It employs the overload principle in which a muscle or muscle group is made to work against a resistance which is greater than that normally experienced by that muscle or muscle group to produce strength. (33) This method is called Progressive Resistance Exercise. Weight training has been the most popular form of progressive resistance exercise. It involves resistive exercise using barbells

and a weight training machine.(4)

Isometric and Isotonic Exercises

Isometric and isotonic exercises are methods of resistive exercises for developing muscular strength, power and endurance. Isometric resistive exercise is accomplished when the skeletal level is prevented from moving by a heavy resistance acting upon it. Isotonic resistive exercise on the other hand is accomplished when the skeletal muscle moves through its full range carrying with it a resistance that is constant.

Evidence abounds which indicates that increases in strength can be produced as a result of isometric and isotonic training (8, 20, 35), but each method has peculiar limitations which impinge on their effectiveness. It has been found that as a result of isometric training, strength is gained only at a point in the range of motion where the greatest resistance is applied during a strength training program. (20, 22, 41) With regard to istonic training, its limitation lies in the fact that the resistance one uses in training at a particular time is constant, but its effect varies through the full range of the joint in action. Thus, muscles or muscle groups contract at differing percentages of their maximum, and thus the greatest effect is on the muscle or muscle group at the extremes in the range of motion.(22, 28, 35) These limitations of both isometric and isotonic exercises are overcome by isokinetic exercises.

Isokinetic Exercise

Isokinetic exercise is a new dimension in the field of resistive exercise. The concept of isokinetic exercise was developed in the Institute of Physical Medicine and Rehabilitation at New York University Medical Center. James Perrine, a bio-engineering consultant, designed the first equipment used in isokinetic exercise. (12)

Isokinetic means same or constant (iso) motion (kinetic). Isokinetic exercise is based upon the control of speed during contraction rather than the amount of load (isotonic) or effort at a specific angle (isometric). The isokinetic contraction resembles the isotonic contraction because the joint moves through a range of motion, but the speed of movement is held constant by the accommodating resistance provided by the machine. (6,27)

Isokinetic instruments provide a range of selectable speeds under the assumption that each speed provides for a maximum resistance (accommodation) throughout the range of movement. The isokinetic device keeps limb motion at a constant predetermined speed: as a subject pushes against the lever arm, the resistance from the machine corresponds to the amount of force the subject pushes against it. The isokinetic machine thus allows a muscle group to develop maximum dynamic tension throughout the range of motion movement at a mechanically fixed rate of speed. The resistance offered by the machine always matches the person's immediate and specific muscular capacity. (5, 29, 30, 44)

Studies using isokinetic exercise as treatment or part of treatments have indicated it to be better than other methods presently used for bringing about increases in muscular strength, power and endurance.

Pipes and Wilmore (32) compared isokinetic and isotonic strength training in adult men. Thirty-six men between 20 and 23 years of age participated in the training program which lasted eight weeks. Subjects were randomly assigned to one of four groups: isogonic; isokinetic low speed, isokinetic high speed; and the control. The training frequency was three days per week, and the training lasted an average of 40 minutes per session. The isotonic group trained at 75 percent of their repetition maximum, there were eight repetitions for each of the three sets; the isokinetic low speed group trained at 24 degrees of limb movement per second for eight repetitions during each of the three sets, while the isokinetic high speed group trained at 136 degrees limb movement per second, fifteen repetitions per set for three sets. The results revealed that the isokinetic low and high speed groups increased significantly over those of either the isotonic or control groups and that the isokinetic high speed group was better than the low speed group.

In another study, Girardi (12) compared isokinetic exercises with isometric and isotonic exercises in the development of muscular strength and endurance. His subjects were high school students. The training lasted fifteen weeks with three four minute training sessions per week. He found at the

end of the study that the isokinetic treatment was more effective in developing muscular strength than the isometric and control treatments. There was no significant difference between his isotonic and isokinetic groups.

McDuffie (25) investigated the effects of the three methods of resistive exercise--isometric, isotonic, and isokinetic--on the time of individual running 100 yards. He used thirty college males and randomly assigned them to the three experimental groups and one control. Training lasted for four weeks and three days per week with the exercises selected to strengthen the knee extensors. Examination of posttest scores indicated that the isokinetic group was significantly different from the other groups. The running time was lower but ANOVA indicated no significance existed among the groups.

In an earlier study by Moffroid (28), which was similar to those mentioned previously, it was concluded that isokinetic exercise is a more effective means of increasing muscular strength throughout the range of motion. It was also stated that isokinetic training increases the work a muscle can do more rapidly than does isometric or isotonic exercises.

Isokinetic instruments provide a range of selectable speeds, and each speed provides an accommodating resistance throughout the range of movement. What effect does different speed have on physiological parameters such as strength, power and muscle endurance? There are limited studies on this aspect of isokinetics. Results generally indicate that differences exist

at different speeds of training. In the Pipes and Wilmore (32) investigation in which he compared isokinetic and isotonic strength training in adult men, through the two isokinetic groups (low and high speeds) were better than the other two groups, and the isokinetic high speed group demonstrated significantly greater strength gains than the isokinetic low speed group.

In another study by Moffroid and Whipple (27) two different training speeds were used, and their effects on muscular strength and muscular endurance were evaluated. They had two goups: slow maximal (low power) and rapid maximal (high power). The training was given for two minutes, three times a week for six weeks. The results revealed the slow maximal exercise group had significant gains in strength at all the six speeds of testing. The improvement in endurance was better for the rapid maximal exercise group than for the slow maximal exercise group.

Wagner (40) investigated the effect of isokinetic exercise on the transfer of strength to the collateral arm. She used six different exercise speeds on the isokinetic exerciser. The subjects were eighteen females. The training program was conducted three times a week for five weeks. Measures were taken of strength, power and electromyelographic activity during the pre and posttests. The results revealed that there was a significant increase in strength of the contralateral arm of the experimental group at the low and medium speeds of contraction. The control group did not show such gains.

Some investigators (6, 28, 32) who have used isokinetic

training claim that the method is more convenient in a number of ways than are the traditional methods of resistive training. Kouskin (17) listed possible advantages of isokinetic exercises as the following:

1. A significant increase in strength and general work ability during a much shorter period of time as compared to other methods of strength preparation now in use.
2. A greater work out of muscle and inclusion of a greater muscle fibers (motor units) into work which results in a greater increase in muscular strength.
3. Time spent on training is significantly decreased.
4. Specificity of training is increased because of the ability to set up one or another speed of isokinetic contractions with the use of the machine.
5. Strength is markedly increased among athletes with long experience in exercising with weight.
6. In view of the light weight and small overall dimensions of the isokinetic apparatus, training can be done outside of the gymnasium.

Resistive Exercise and Women

Female participation in resistive exercise is quite recent. The lack of participation in such exercise is connected with the acceptance of unscientific assertions that resistive exercise would lead to muscle boundness and masculinity in women.

Studies have shown that these assertions are false.

Wilmore (43), in his investigation of Body Composition and Strength Development, showed that women can develop strength from weight training with little gain in muscle girth. In a recent study, Wilmore (42) investigated alteration in strength, body composition and anthropometric measures as a result of a ten week weight training program. His subjects were 47 women and 26 men. The treatment was a 10 week program of intensive weight training two days per week for forty minutes each session. Results show that both groups made similar relative gain in strength and absolute gain in body composition. The results also show that though men are stronger for all strength measures, women exhibited a greater leg strength when expressed relative to lean body weight.

Yet in another study on women, Mayhew and Gross (21) conducted a study on body composition changes in young women with high resistance weight training. The subjects were 17 college women, and the treatment was a 9 week program of intensive weight training for 3 days per week for 40 minutes each session. They found significant increase in body mass among others. In their own words they concluded

> That high resistance weight training can enhance feminine body composition without concomitant masculinizing effect or marked changes in body weight.(21)

> It has been found that females have the potential to develop high level of strength through training without the resultant gains in muscle build as men. The inability of the average female to increase in muscle bulk with strength training is said to be connected with her

relatively low level of male hormone testosterone compared with an average male.(41)

Some studies have been conducted on isokinetic exercise with women as subjects, but they are limited in number and scope.

Oteghen (20) studied the effects of two speeds of isokinetic exercise on vertical jump of women. The subjects were forty-eight female varsity and second team intercollegiate volleyball players from four universities. The treatment was three sets of leg presses for ten repetitions. The training was conducted for eight weeks, three days per week. There were two experimental groups: slow and fast, and a control group. Results indicated that the slow and the fast isokinetic groups were significantly better than the control group in vertical jump performance The slow speed isokinetic group improved significantly on strength measure than did the control group.

In a similar study, McKenzie (26) used twenty four female subjects and assigned them to two groups, one experimental and one control group. The treatment was high speed and high repetitions isokinetic training on isokinetic leaper. Twenty five parallel squats was performed three times per week for eight weeks on isokinetic leaper. The results revealed significant increase in strength and jumping ability for the experimental group.

Knight (16) made a comparison of three isokinetic training velocities on muscular power development in college women. Subjects were assigned to one of four groups according to the average of their pretest scores in vertical jump and power

staircase test. The three experimental groups performed some isokinetic exercises at different present speeds of .8, 2.3 and 3.0 inches per second. The training lasted six weeks. Results incidate that the three experimental groups improved significantly in leg power, but no one speed was significantly more effective as revealed by the results of the three power tests.

Muscular Strength, Power and Endurance

Strength is the force that a muscle or muscle group can exert against as resistance in one maximum effort. (22) Results of animal experiments have been used to demonstrate the fact that increased strength and cross sectional area in muscles are related to increases in myofibrillar protein (actin and myosin). Strength development is accomplished through resistive training. It has also been suggested that strength can be developed by increasing the mobilization of motor units activated per contraction and by increasing the frequency of impulse to the activated motor units. (10)

Muscular endurance is the ability to perform prolonged bouts of work without experiencing fatigue or exhaustion. (41) Endurance can be determined when an individual through training can (1) repeat a particular movement for a longer time than was previously possible, (2) repeat a particular movement for a longer time than was previously possible, or (3) repeat the movement for a set time period with an increased load. (41) With enduarnce training, the oxidative capacity of the muscle is

increased. There is also lower muscle and blood lactate as well as lower rate of glycogen depletion. The capillarization is also increased with endurance training. (23, 24, 25)

Power is the rate of doing work, and it is usually determined by the speed at which a maximum load can be moved. (10) Power is increased substantially through training; an increase in power is usually a result of improvement in either strength or speed or both.

Strength is a factor in endurance and power. In muscular endurance, muscles are involved in continuous contractions; and each contraction is dependent on the force the muscles can generate. As for power, it depends on the capability of a muscle or a muscle group to generate force and at what rate. Strength is a critical factor in the expression of power. However, absolute strength does not seem to be as important as power for most athletic activities. Also, as the endurance components of an event or activity increases, the power and strength components dexrease. (10)

Summary

Muscular strength, power and endurance are components of functional performance in athletics and sports. They can be developed through resistive exercise. Isomettic or static and isotonic or dynamic exercise are both resistive training, but they have disadvantages which are overcome by isokinetic training.

Through resistive exercises women can also improve their muscular strength, power and endurance without developing muscle bulk which normally accompanies strength training in men.

CHAPTER 3

METHOD OF RESEARCH

The study investigated the effects of slow and fast speeds of isokinetic training on muscular strength, power and endurance for college females. The study lasted seven weeks.

This chapter is divided into the following sections to make for clear description of the procedures used in the investigation:

1. Subjects
2. Pretraining Tests
3. Training Program
4. Posttraining Tests
5. Instrumentation
6. Statistical Procedure for Interpreting the Data.

Subjects

The subjects were thirty college females at Western Kentucky University who consented to take part in the study. (See Appendix I for consent form). Twenty of the subjects were from the Figure Contour Improvement Class and they served as the experimental groups. Ten subjects who served as the control group were from the Bowling Class.

The initial selection of the possible experimental subjects was done randomly but the final subjects for the

experimental group were volunteers who were randomly assigned to the two experimental groups. The initial selection of possible experimental subjects was done by randomly selecting twenty eight names from the registration lists of two Figure Improvement Classes N-46. The first twenty who volunteered from the twenty eight that were randomly selected were chosen as subjects for the experimental groups. The ten subjects who served as subjects for the control group were volunteers from a Bowling Class.

The experimental subjects were randomly assigned to one of the two experimental groups after matching based on the pre-test scores on strength measure. The two experimental groups were: 1) Isokinetic Slow Speed and 2) Isokinetic Fast Speed groups. The peak torque scores on strength measure for all subjects were arranged in a descending order from the highest to the lowest: the scores were then paired so that the top were the two highest strength measures and the bottom were the two lowest strength measures. The two subjects in each pair were randomly assigned to the two experimental groups.

Pretest

Muscular strength, power and muscular endurance were the variables of the knee extensor muscles measures; both legs were used in the measurements. Lumex isokinetic equipment- Cybex II a dynamic accommodating resistance instrument, was used in assessing the three variables.

For muscular strength, subjects were tested at 30 degrees

revolution per second which is equivalent to #2½ velocity training speed for the slow speed group. Each subject, after stretching and joint mobilizing exercises, was asked to perform two submaximal contractions for practice so as to get a feel of the accommodating resistance provided by the machine at the 30 degrees revolution per second. This was followed by three maximal repetitions of the knee extension until no more movement was possible at the knee joint. There was reciprocal resistance on the flexion.

The criterion strength measure was the highest peak torque in the foot pound for the test period. This was recorded on the paper chart with the subject's name and date. The angle of the knee joint at the start of measurement was approximately 65 degrees, as this has been found to be the angle at which the knee extensor muscles can exert the greatest force (30). Slow (5mm/sec) chart paper speed was selected for recording the strength measures.

Power was measured on the Cybex II at 180 degrees revolution per second and a fast (25mm/sec) chart paper speed on the recorder was selected. Each subject was asked to do two submaximal contractions for practice so as to get used to the machine at the selected speed. Subjects were instructed to concentrate on performing explosive and powerful knee extension with maximum effort. The highest value of torque in three repetitions was the criterion power measure.

Muscular endurance was also measured on Cybex II at 180 degrees revolution per second. Slow (5mm/sec) chart paper was

selected for recording the muscular endurance measures. Each subject was asked to practice two submaximal contractions in order to get a feel of the machine at the selected speed. Subjects were asked to concentrate on performing explosive and powerful knee extensions continuously until asked to stop. The subjects were asked to stop when several successive repetitions were below 50 percent of the starting peak. The unfatigued high velocity contractions in the power test were used as the 100 percent values and one-half of the vertical grid line on the chart was noted. Muscular endurance was defined as the number of repetitions in each direction to accomplish each subject's 50 percent fatigue.

Training Program

Each of the experimental subjects performed knee extensions on the Lumex Orthotron. The Orthrotron is a system for providing isokinetic resistive exercise to the knee, ankle and shoulder muscles. It provides an automatic accommodating resistance which matches an exercise force output at each point in the range of motion (46). The training frequency was three days per week and the study lasted seven weeks.

The isokinetic slow speed group trained at number 2½ velocity on the Orthotron which is equivalent to about 30 degrees revolution per second on Cybex II for three sets, each of which lasted twenty seconds. The isokinetic fast speed group trained at number 7 velocity on the Orthotron, equivalent to about

180 degrees revolution per second on the Cybex, for three sets of twenty seconds each.

The training program for each session followed very closely the outline below.

1. Stretching and joint movilizing exercises for four minutes.

In the following exercises, the subjects were paired according to the experimental group to which they had been assigned. The pairs were assigned to five stations; one member of each pair performed while the other rested. After the exercise at each station was completed, the whole group rotated one station to the right.

2. Right knee extension on the Orthotron for twenty seconds, rest for thirty seconds while partner did her left knee extension on the left arm of the Orthotron. Three sets of twenty second repetitions were done for each leg.
3. Three sets of bench presses on the Lumex isokinetic machine, each set lasting twenty seconds.
4. Three sets of sit-ups with the legs folded. Each repetition lasted twenty seconds.
5. Three sets of burpees, each set lasting twenty seconds.
6. Three sets of push-ups each set lasting twenty seconds.

To offset training effect, each subject worked with two members from her experimental group and pairings were changed

during each training session. It took five training sessions to complete each rotation.

There were two training sessions, three days per week. There were ten subjects in each training session and the subjects in the first training session had six members who belonged to the slow speed group and four members who belonged to the fast speed group. The ten subjects in the second training session had six fast speed and four slow speed members.

A master card, and a score card for each subject were kept by the investigator. The score card for each subject was initialed by the investigator to keep a record of attendance during the training session. A subject who missed a training session had to make up the missed training the following day.

Orientation

Part of the first two training sessions was devoted to orientating subjects to the testing procedure and the apparatus to be used in the training and measurements.

Posttest

The same procedures adopted during the pretest were used at the termination of training. The variables measured were muscular strength, power and endurance.

Instrumentation

Cybex II isokinetic machine by Lumex, Inc. was used as

the instrument for measurement. It was calibrated for the tests according to the instructions from the manufacturer. The Orthrotron, another Lumex isokinetic machine, was used as the training machine for the treatment. The isokinetic bench press machine by Lumex was used as a supplementary machine for the bench press exercise.

Statistical Procedures

The statistical procedure adopted was the Analysis of Variance (ANOVA), to test if there were differences between the three groups on the pretest data in the eight variables measured. Analysis of Covariance (ANCOVA) was used to determine if there were any significant differences after correcting for the initial difference between the three treatment groups. Duncan's multiple range test was used to separate the significantly different means.

CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

Introduction

This chapter presents the effects of the two speeds of isokinetic training on the development of muscular strength, power and endurance. The Cybex II isokinetic machine was used to measure muscular strength, power and endurance on the subject's right and left legs. The research hypotheses stated in Chapter One were tested through statistical analysis. Two statistical analyses were made for each type of measurement. The frist was the analysis of variance (ANOVA) to determine if there was any statistically significant difference between the pretest measures of the three groups. The second analysis was to determine if there was any significant difference after correcting for the initial difference between the three treatment groups; an analysis of covariance (ANCOVA) was used for this. Duncan's multiple range test was used to separate the significant means.

This chapter is organized into the following: 1) Analysis of the muscular strength measures and testing of the hypothese for strength; 2) analysis of Power I and II measures and testing of the hypotheses for power measures; 3) analysis of muscular endurance

measures and testing of the hypotheses for muscular endurance measures.

The Analysis of Strength Measures

In order to determine whether or not the experimental treatment has been effective in bringing about improvement in muscular strength, the hypothesis that no difference exists between the pretest strength measures was tested for the experimental and control groups. The hypothesis of no significant difference in terms of posttest muscular strength between the three treatment groups was also tested. A summary of the analysis on strength measures is given in Table I.

TABLE I

SUMMARY OF ANALYSIS OF VARIANCE FOR DIFFERENCES BETWEEN TREATMENT GROUPS ON THE PRETEST STRENGTH MEASURE FOR RIGHT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Treatment	277.00	2	138.700	0.531 ns
Residual	7058.867	27	261.439	
Total	7336.270	29	252.975	

ns denotes not significant.

The analysis of variance of the pretest scores on strength for the right knee extension showed no significant difference between the groups.

TABLE II

SUMMARY OF THE PRE AND POSTTEST MEANS FOR TREATMENT GROUPS ON STRENGTH MEASURE FOR RIGHT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	102.00	112.20
Slow Speed	103.60	110.70
Control	96.50	92.80

Comparison of the pretest and posttest means showed improvement in two of the three groups. The control group showed a decrease in the posttest measure. No adequate explanation can be given for this since the control group participated in bowling. A probable explanation may be that the right leg was not used much. Since all subjects were right handed, at the moment of release of the ball, the left foot must be used to pivot while the right leg is used for support.

TABLE III

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON POSTTEST STRENGTH MEASURE FOR RIGHT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Covariates Pre SR	4762.746	1	4762.746	61.889 *
Treatment	1309.743	2	654.871	8.510 *
Residual	2000.848	26	76.956	
Total	8073.336	29	278.391	

*$P < .05$

Analysis of covariance of the posttest measure after adjusting for pretest measures revealed a significant difference between the groups at the .05 level.

Since a significant difference was found in the analysis of covariance, the Duncan multiple range test was used to separate the significant means.

The results of the multiple range test on the posttest means on strength for the right knee extension are summarized in Table IV.

TABLE IV

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON STRENGTH RIGHT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means *	92.80	110.70	112.20	
Control	1	2		R_2 4.62
Slow Speed		2	3	R_3 4.86

* The group with the lowest pretest mean is on the left; the group with the highest is on the right. If two or more groups are joined by a line below, it shows that the difference(s) is/are not significant at the .05 level.

The multiple range test shows that the slow and fast speed groups are significantly different from the control group, but there is no significant difference between the two experimental groups.

TABLE V

SUMMARY OF ANALYSIS OF VARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON PRETEST STRENGTH MEASURE FOR LEFT KNEE EXTENSION.

Source of Variation	Sum of Squares	DF	Means Squares	F
Treatment	880.886	2	440.443	1.660 ns
Residual	7162.469	27	265.277	
Total	8043.336	29	227.356	

ns denotes not significant.

The analysis of variance between the three experimental groups for the pretest scores on strength measure of the left knee extension indicates no significant difference between the groups.

TABLE VI

SUMMARY OF THE PRE AND POSTTEST MEANS FOR TREATMENT GROUPS ON STRENGTH MEASURE FOR THE LEFT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	100.60	109.10
Slow Speed	98.50	107.00
Control	88.20	89.90

The comparison of the pre and posttest means indicates greater improvement in the fast and slow speed groups than in the control group.

TABLE VII

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON POSTTEST STRENGTH MEASURE FOR LEFT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Covariates Pre SL	5175.357	1	5175.457	117.626 *
Treatment	612.586	2	306.293	6.949 *
Residual	1145.930	26	44.074	
Total	6933.978	29	239.102	

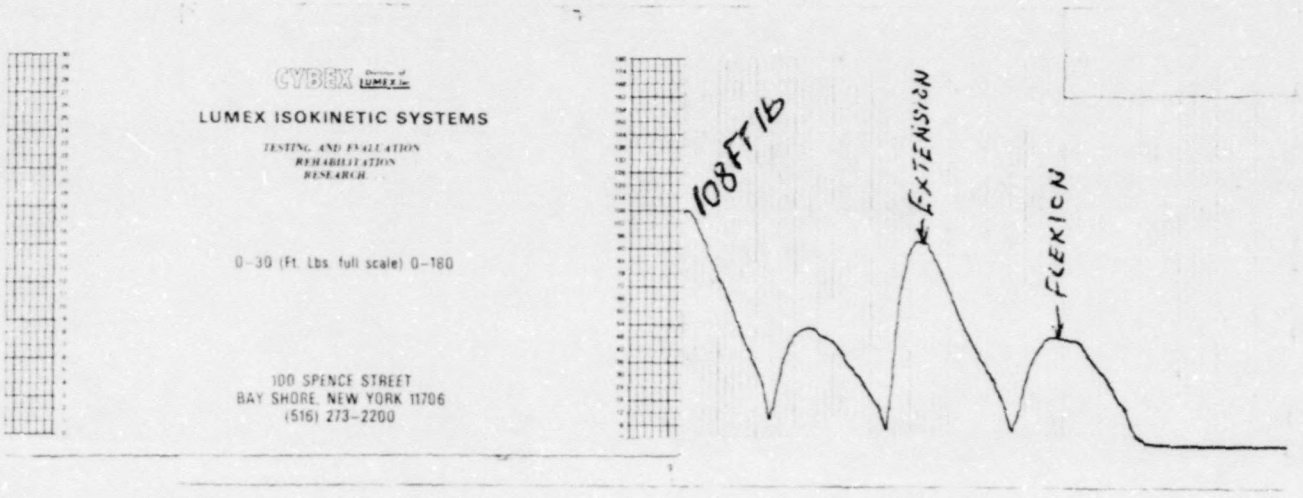
* $P < .05$

Analysis of covariance carried out on the posttest measure after adjusting for pretest scores indicates that a significant difference exists between the groups at the .05 level.

A Duncan's multiple range test was carried out to separate the significant means. The results of the test are shown in Table VIII.

FIGURE I

STRENGTH MEASURE



Strength measure taken from the peak of the highest curve of three knee extensions.

TABLE VIII

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON STRENGTH LEFT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means*	89.90	107.00	109.10	
Control	1	2		R_2 3.51
Slow Speed		2	3	R_3 3.68

* The group with the lowest pretest mean is on the left; the group with the highest is on the right. If two or more groups are joined by a line below, it shows that the difference(s) is/are not significant at the .05 level.

Results of the multiple range test show that there are significant differences between groups 1 and 2 and groups 1 and 3, but there is no significant difference between groups 2 and 3, the fast and the slow speed groups.

The hypotheses concerning muscular strength stated in Chapter One were:

1. There will be no significant difference in posttest muscular strength between the three groups after correcting for initial level of strength for the right knee extension.

2. There will be no significant difference in posttest muscular strength between the three groups after correcting for initial level of strength for the left knee extension.

On the basis of the results of the study on muscular

strength, the hypothesis that there will be no significant difference in posttest muscular strength between the three groups after correcting for initial level of strength for the right knee extension is rejected since there was significant difference between the groups. The experimental groups were significantly different from the control group but were not different from each other.

The hypothesis that there will be no significant difference in terms of posttest muscular strength between the three groups after correcting for initial level of strength for the left knee extension is also rejected since there was significant difference between the groups. The experimental groups were significantly different from the control group.

The Analysis of Power Measures

The analysis of power measures was carried out to determine the effect of the experimental treatments on the experimental and control groups. The hypothesis that no difference exists between the pretest scores was tested for the experimental and control groups. The hypothesis of no significant difference in terms of posttest Power I and II between the three groups after correcting for initial level of power was also tested.

Power was measured in two ways. Power I was measured by using the peak of the curve in the test to arrive at the power measure. Power II was measured by using a unit time of .2 seconds to estimate the amount of power each subject generated

during the first .2 seconds in the power test.

A summary of the analysis on power measure is given in the following:

TABLE IX

SUMMARY OF THE ANALYSIS OF VARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON PRETEST POWER I MEASURE FOR RIGHT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Treatment	4749.266	2	2374.633	3.843 *
Residual	16685.668	27	617.988	
Total	21434.934	29	739.135	

* $P < .05$

Analysis of variance between the pretest Power I measures for the experimental and control groups indicates that a significant difference exists between the groups. A multiple range test was conducted to separate the significant means. Results indicated no significant difference between the three group means. The multiple range test is presented in Table X.

TABLE X

MULTIPLE RANGE TEST FOR THE PRETEST MEANS ON POWER I RIGHT KNEE EXTENSION.

	Fast Speed	Slow Speed	Control	Shortest Significant Range
Means *	117.40	130.40	148.10	
Fast Speed	1	2		R_2 14.60
Slow Speed		2	3	R_3 15.75

* The group with the lowest pretest mean is on the left; the group with the highest is on the right. If two or more groups are joined by a line below, it shows that the difference(s) is/are not significant at the .05 level.

Since the analysis of variance indicated that a significant difference existed between the pretest Power I measure for the right leg, analysis of covariance was carried out to correct for the inital difference when comparing posttest measures.

TABLE XI

SUMMARY OF THE PRE AND POSTTEST MEANS FOR THE TREATMENT GROUPS ON POWER I MEASURE FOR THE RIGHT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	117.40	194.50
Slow Speed	130.40	174.00
Control	148.10	151.70

A comparison of the pre-and posttest means reveals improvement in all the three groups, with the fast speed group having the largest gain followed by the slow speed group and then the control group.

TABLE XII

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON THE POSTTEST POWER I MEASURE FOR THE RIGHT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Covariates Pre PR I	1158.570	1	1158.570	2.205 *
Treatment	16024.949	2	8012.473	15.249 *
Residual	13661.637	26	525.448	
Total	30845.156	29	1063.626	

* $P < .05$

The analysis of covariance on the posttest measure after adjusting for the pretest reveals that a statistically significant difference exists between the treatment groups at the .05 level. The Duncan's multiple range test was carried out to separate the significant means. The result is shown in Table XIII.

TABLE XIII

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON POWER I FOR THE RIGHT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means *	151.70	174.00	194.50	
Control	1	2		R_2 12.12
Slow Speed		2	3	R_3 12.70

* The group with the lowest pretest mean is on the left; the group with the highest is on the right.

The multiple range test shows that a significant difference exists between the three groups. The fast speed group is significantly better than either the control or the slow speed group. The slow speed group is significantly better than the control group.

TABLE XIV

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON THE POSTTEST POWER I MEASURE FOR LEFT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Treatment	868.866	2	434.433	.822 ns
Residual	14268.465	27	528.461	
Total	2297.331	29	78.217	

ns denotes not significant

Analysis of variance between the pretest Power I measure for the treatment groups indicates no significant difference between them.

TABLE XV

SUMMARY OF THE PRE AND POSTTEST MEANS FOR THE TREATMENT GROUPS ON POWER I MEASURE FOR THE LEFT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	130.00	184.40
Slow Speed	125.90	155.10
Control	138.80	143.30

A comparison of the pretest and posttest means shows that the posttest means for the three are better than those of the pretest. The fast speed group made the largest gain followed by the slow speed group and then the control group.

TABLE XVI

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCES BETWEEN TREATMENT GROUPS ON THE POSTTEST POWER I MEASURE FOR LEFT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Covariates Pre PR I	5816.250	1	5816.250	23.475 *
Treatment	1157.684	2	5578.840	22.846 *
Residual	6441.898	26	247.765	
Total	23415.832	29	807.442	

* $P < .05$

Analysis of covariance after adjusting for the pretest measure indicates that there is significant difference between the treatment groups at the .05 level.

The separation of the significant means was done by using Duncan's multiple range test. The result is present in Table SVII.

TABLE XVII

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON POWER I MEASURE FOR LEFT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means*	143.30	155.10	184.40	
Control	1	2		R_2 8.32
Slow Speed		2	3	R_3 8.27

* The group with the lowest pretest mean is on the left; the group with the highest is on the right.

The multiple range test reveals that the three groups are significantly different from one another. The fast speed group is significantly better than the slow speed and the control groups; the slow speed group is significantly better than the control group.

TABLE XVIII

SUMMARY OF THE ANALYSIS OF VARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON PRETEST POWER II MEASURE FOR RIGHT KNEE EXTENSION.

Source of Variation	Sum of Squares	DF	Means Square	F
Treatment	3760.066	2	1880.033	2.137 ns
Residual	23757.363	27	879.902	
Total	27517.430	29	948.877	

ns denotes not significant

Analysis of variance for the pretest Power II scores for the treatment groups shows that no significant difference exists at the initial stage between the three groups.

TABLE XIX

SUMMARY OF PRE AND POSTTEST MEANS FOR THE TREATMENT GROUPS ON POWER II MEASURE FOR THE RIGHT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	181.50	275.50
Slow Speed	179.00	226.00
Control	203.90	207.70

A comparison of the pre-and posttest means of the three treatment groups reveals improvement in all the groups. However, the gains differ for the groups. The fast speed group made the largest gain followed by the slow speed group then by the control group, which made only a slight improvement.

TABLE XX

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON POSTTEST POWER II MEASURE FOR RIGHT KNEE EXTENSION.

Source of Variation	Sum of Squares	DF	Means Square	F
Covariates Pre PR II	3926.325	1	3926.325	7.774 *
Treatment	32227.734	2	16113.867	31.906 *
Residual	13131.090	26	505.042	
Total	49285.152	29	1699.488	

* $P < .05$

Analysis of covariance on the posttest Power II measure after adjusting for pretest indicates the significant difference exists between the treatment groups at the .05 level. Duncan's multiple range test was used to separate the significant means. The result is shown in Table XXI.

TABLE XXI

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON POWER II FOR RIGHT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means*	207.70	226.00	275.50	
Control	1	2		R_2 11.86
Slow Speed		2	3	R_3 12.43

* The group with the lowest pretest mean is on the left; the group with the highest is on the right.

The results of the multiple range test shows that significant differences exist between the three treatment groups. The fast speed group is significantly different from the slow speed and control groups. The slow speed group is significantly different from the control and fast speed groups.

TABLE XXII

SUMMARY OF THE ANALYSIS OF VARIANCE FOR DIFFERENCES BETWEEN TREATMENT GROUPS ON PRETEST POWER II MEASURE FOR LEFT KNEE EXTENSION.

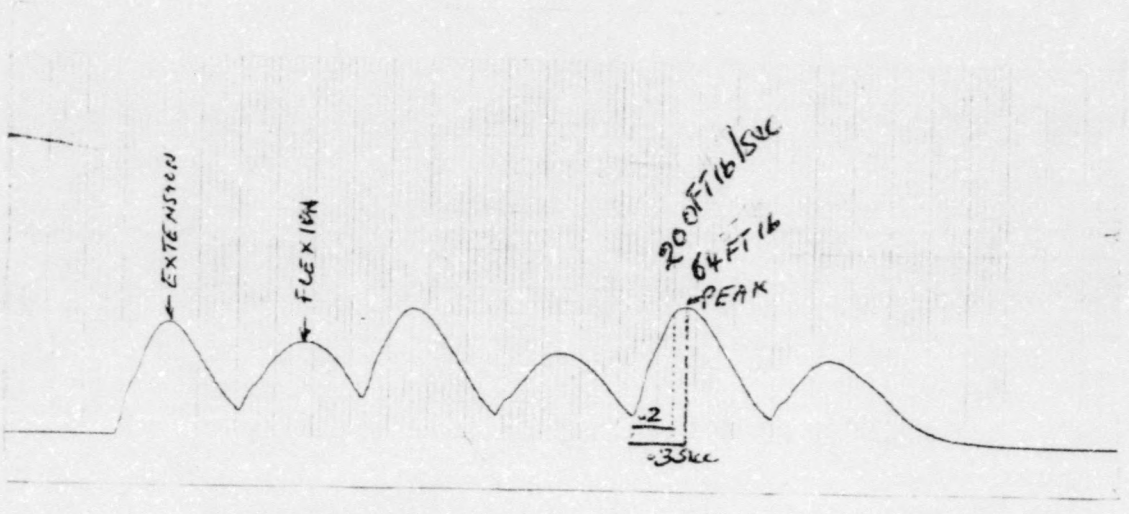
Sources of Variation	Sum of Squares	DF	Means Square	F
Treatment	322.400	2	161.200	0.170 ns
Residual	25533.863	27	945.698	
Total	25856.266	29	891.595	

ns denotes not significant

Analysis of variance on the pretest measure for Power II left knee extension shows no significant difference between the treatment groups.

FIGURE II

POWER MEASURES



Power measures taken from the curve with highest peak.

Power I taken from peak of curve.

Power II taken from intersection of .2 sec. on the curve.

TABLE XXIII

SUMMARY OF THE PRE AND POSTTEST MEANS FOR THE TREATMENT GROUPS ON THE POWER II MEASURE FOR LEFT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	189.50	244.00
Slow Speed	181.50	213.00
Control	186.10	192.00

Comparison of the pre- and posttest means for the experimental and control groups shows that the three groups improved over the pretest measure. The fast speed group made the largest gain followed by the slow speed group, then the control group.

TABLE XXIV

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCES BETWEEN TREATMENT GROUPS ON THE POSTTEST POWER II MEASURE FOR THE LEFT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Covariates Pre PL.II	21809.707	1	21809.707	105.855*
Treatment	11974.035	2	5987.016	29.058*
Residual	5356.879	26	206.034	
Total	31940.621	29	1349.677	

* $P < .05$

Analysis of covariance after adjusting for the pretest measure reveals that a significant difference exists between the treatment groups at the .05 level.

Duncan's multiple range test was used to separate the significant means. The result of the test is presented in Table XXV.

TABLE XXV

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON THE POWER II MEASURE FOR LEFT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means *	192.00	213.00	244.00	
Control	1	2		R_2 7.59
Slow Speed		2	3	R_3 7.96

* The group with the lowest pretest mean is on the left; the group with the highest is on the right.

Results of the multiple range test indicate significant differences between the treatment groups. The fast speed group is significantly different from the slow speed and control group, while the slow speed group is significantly different from the control and fast speed groups.

The hypotheses stated in Chapter One have been changed:

3. There will be no significant difference in terms of posttest Power I between the three groups after correcting for initial level of Power I for the right knee extension.

4. There will be no significant difference in terms of posttest Power I between the three groups after correcting for initial level of Power I for the left knee extension.

5. There will be no significant difference in terms of

posttest Power II between the three groups after correcting for initial level of Power II for the right knee extension.

6. There will be no significant difference in terms of posttest Power II between the three groups after correcting for initial level of Power II for the left knee extension.

Based on the results of the study on Power I and II, hypotheses three, four, five and six were rejected because results indicate that differences exist between the three treatment groups. The experimental groups were different from the control group as well as from each other.

The Analysis of Endurance Measures

The analysis of the endurance measures was carried out to determine the effects of experimental treatments on the experimental and control groups. The hypothesis that there will be no significant difference in terms of the posttest endurance between the three groups after correcting for initial level of endurance for the right and left knee extension was also tested.

TABLE XXVI

SUMMARY OF THE ANALYSIS OF VARIANCE FOR DIFFERENCES BETWEEN GROUPS ON THE PRETEST ENDURANCE MEASURE FOR RIGHT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Treatment	24.967	2	12.433	0.479 ns
Residual	700.998	27	25.963	
Total	725.865	29	25.030	

ns denotes not significant.

Analysis of variance between the pretest measure on endurance for the experimental and the control groups indicates that no statistically significant differences exist between the three groups.

TABLE XXVII

SUMMARY OF THE PRE AND POSTTEST MEANS FOR THE TREATMENT GROUPS ON THE ENDURANCE MEASURE FOR RIGHT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	21.00	33.40
Slow Speed	18.90	21.10
Control	19.30	19.30

A comparison of the pre- and posttest means reveals that improvement took place in two of the three groups. The fast and the slow speed groups show some improvement over the pretest measure while the control group remains the same as the pretest measure.

The fast speed group made the largest gain of 12.40 and the slow speed group made a gain of 2.20 over the pretest scores.

TABLE XXVIII

SUMMARY OF ANALYSIS OF COVARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON THE POSTTEST ENDURANCE MEASURE FOR RIGHT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Covariates Pre ER	411.907	1	411.907	35.007 *
Treatment	475.367	2	487.684	41.448 *
Residual	305.923	26	11.766	
Total	1693.197	29	58.386	

*P $<$ .05

The analysis of covariance on the posttest measure after adjusting for the pretest scores reveals that a statistically significant difference exists between the treatment groups at the .05 level. The Duncan multiple range test was carried out to separate the significant means. The results are presented in Table XXIX.

TABLE XXIX

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON THE ENDURANCE MEASURE FOR RIGHT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means*	19.30	21.10	33.40	
Control	1	2		R_2 1.79
Slow Speed		2	3	R_3 1.88

* The group with the lowest pretest mean is on the left; the group with the highest is on the right.

The results of the multiple range test show that significant differences exist between the means of the three treatment groups. The fast speed group is significantly different from the other two. The slow speed group is significantly different from the fast speed and the control group.

TABLE XXX

SUMMARY OF THE ANALYSIS OF VARIANCE FOR DIFFERENCE BETWEEN TREATMENT GROUPS ON PRETEST ENDURANCE MEASURE FOR LEFT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Means Square	F
Treatment	163.800	2	81.900	3.345 *
Residual	660.998	27	24.481	
Total	824.798	29	28.441	

* $P < .05$

Analysis of variance performed on the pretest endurance measure for the left knee extension indicates that a significant difference exists between the treatment groups.

Duncan's multiple range test was conducted to separate the significant means. The results of the test are shown in Table XXXI.

TABLE XXXI

MULTIPLE RANGE TEST FOR THE PRETEST MEANS ON THE ENDURANCE MEASURE FOR LEFT KNEE EXTENSION.

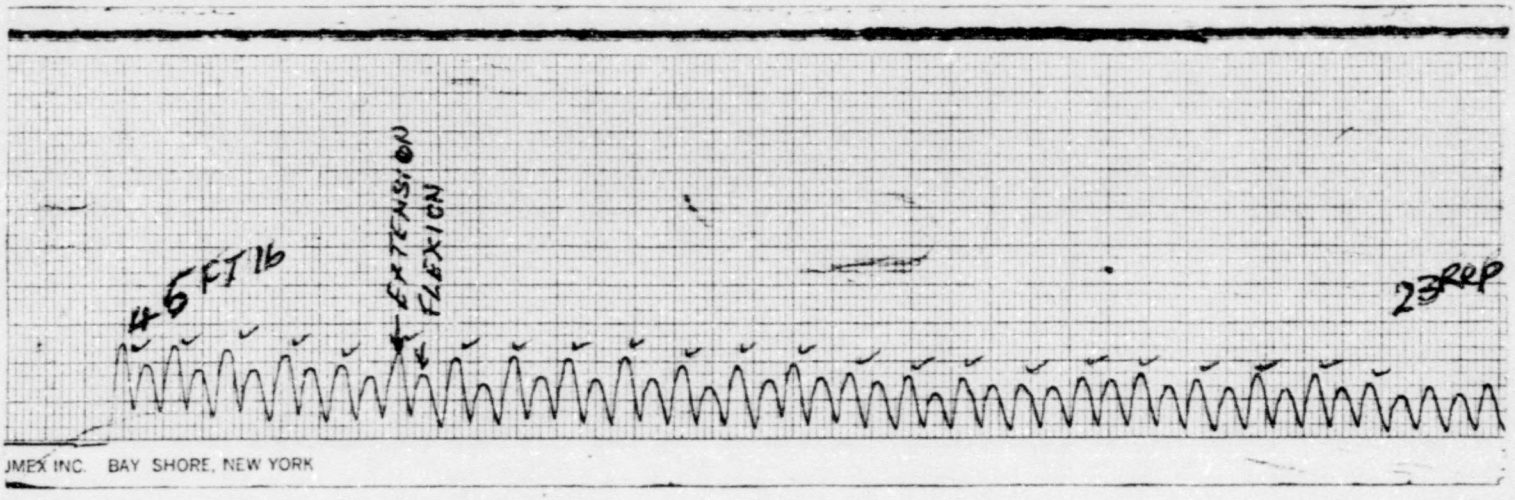
	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means*	15.80	19.10	21.50	
Control	1	2		R_2 2.61
Slow Speed		2	3	R_3 2.74

* The group with the lowest pretest mean is on the left; the group with the highest is on the right. If two or more groups are joined by a line below, it shows that the difference(s) is/are not significant at the .05 level.

Duncan's multiple range test reveals that the slow speed group is significantly different from the control group and that the fast speed group is significantly different from the control group; but there is no significant difference between the slow and fast speed groups.

FIGURE III

ENDURANCE MEASURE



The endurance measure is determined by the number of repetitions of the knee extension it takes to attain one-half of the highest curve.

TABLE XXXII

SUMMARY OF THE PRE AND POSTTEST MEANS FOR THE TREATMENT GROUPS ON THE ENDURANCE MEASURE FOR LEFT KNEE EXTENSION.

Treatment Groups	Pretest Means	Posttest Means
Fast Speed	21.50	31.00
Slow Speed	19.10	21.70
Control	15.80	18.00

Comparison of the pre- and posttest means for the three groups shows that all the three groups' performances in the posttest improved over the pretest means. The fast speed group made the largest gain of 9.50 points followed by the slow speed group which had a gain of 2.60. The control group made a gain of 2.20 which is close to the gain of the slow speed group.

TABLE XXXIII

SUMMARY OF ANALYSIS OF COVARIANCE FOR THE DIFFERENCE BETWEEN TREATMENT GROUPS ON THE POSTTEST ENDURANCE MEASURE FOR THE LEFT KNEE EXTENSION.

Sources of Variation	Sum of Squares	DF	Mean Square	F
Covariates Pre EL	712.133	1	712.133	65.936 *
Treatment	432.422	2	216.211	20.019 *
Residual	280.810	26	10.800	
Total	1425.365	29	49.150	

* P .05

Analysis of covariance on the posttest measure after adjusting for the pretest scores reveals that a statistically significant difference exists between the treatment groups at the .05 level.

Duncan multiple range test was carried out to separate the significant means. The result is shown in Tabke XXXIV.

TABLE XXXIV

MULTIPLE RANGE TEST FOR THE POSTTEST MEANS ON ENDURANCE FOR LEFT KNEE EXTENSION.

	Control	Slow Speed	Fast Speed	Shortest Significant Range
Means*	18.00	21.70	31.00	
Control	1	2		R_2 1.74
Slow Speed		2	3	R_3 1.82

* The group with the lowest pretest mean is on the left; the group with the highest is on the right.

Duncan's multiple range test indicates that a significant difference exists between the means of the three groups. Both the fast and slow speed groups are significantly different from the control group. Also, the fast speed group is significantly different from the slow speed group.

The hypotheses stated in Chapter One have been changed:

7. There will be no significant difference in posttest endurance between the three groups after correcting for the initial level of endurance for the right knee extension.

8. There will be no significant difference in posttest endurance between the three groups after correcting for the initial level of endurance for the left knee extension.

On the basis of the results of this study on muscular

endurance, hypotheses seven and eight were rejected because differences exist between the three treatment groups after correcting for the initial level of endurance for the right and left knee extension.

Summary

The purpose of this chapter was to present and analyze the data collected in this investigation. The results of the study revealed significant changes in muscular strength, power and endurance.

A summary of the means and significant differences is presented in Table XXXV.

TABLE XXXV

SUMMARY OF SIGNIFICANT DIFFERENCES FOR THE PRE AND POSTTEST MEASURES FOR STRENGTH, POWER AND ENDURANCE.

	PRETEST		
	Control	Slow Speed	Fast Speed
Strength			
Right	96.50	103.60	102.00 ns
Left	88.20	98.50	100.60 ns
Power I			
Right	148.10	130.40	117.40 *
Left	138.80	125.90	130.00 ns
Power II			
Right	203.90	179.00	181.50 ns
Left	186.10	181.50	189.50 ns
Endurance			
Right	19.30	18.90	21.00 ns
Left	15.80	19.10	21.50 *

ns denotes not significant.

* denotes significant difference at the .05 level.

If two or more groups are joined by a line below, it shows that the difference(s) is/are not significant at the .05 level.

TABLE XXXV

(Continued)

	POSTTEST		
	Control	Slow Speed	Fast Speed
Strength			
Right	92.80	110.70	112.70 *
Left	89.90	107.00	109.10 *
Power I			
Right	151.70	174.00	194.50 *
Left	143.30	155.10	184.40 *
Power II			
Right	207.70	226.00	275.50 *
Left	192.00	213.00	244.00 *
Endurance			
Right	19.30	21.10	33.40 *
Left	18.00	21.70	31.10 *

* Denotes significant difference at the .05 level.

If two or more groups are joined by a line below, it shows that the difference(s) is/are not significant at the .05 level.

CHAPTER 5

SUMMARY, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this investigation was to study the effects of two speeds of isokinetic training on muscular strength, power and endurance of college females.

Thirty college females, twenty from two Figure Contour Improvement classes and ten from a Bowling class, were pretested on four variables: muscular strength, Power I, Power II and endurance. The twenty subjects who served as the experimental subjects were randomly assigned to two experimental groups after matching on pretest strength measures. After the pretest, the experimental subjects trained for seven weeks, three days per week; the training was held on alternate days. The experimental treatment was isokinetic training for right and left knee extension. There were three sets of knee extension for each leg; each set lasted twenty seconds with a thirty second rest between sets. There were two training speeds: fast and slow. The fast speed group trained at # 7 speed on the Orthotron while the slow speed group trained at #2½ speed. The speeds were approximately 180 and 30 degrees revolution per second respectively on the Cybex II, which was the testing equipment. Four other

supplementary exercises were included in the training program: push-ups, bench presses, sit-ups, and burpees. At the end of the training period, the subjects were tested in a manner identical to that of the pretest. The statistical procedure used for the analysis of the data was the analysis of variance, to test for differences between treatment groups on the pretest measures. Means of the pretests and posttest for each group were compared to determine gains. Analysis of covariance was used for the posttest measure, with the pretest measure as covariates for each of the eight variables.

The results of the statistical analysis revealed statistically significant differences in all the eight variables for the posttest scores. The experimental groups were significantly different from the control group. The fast speed group was also significantly different from the slow speed group in all but two of the eight variables: the strength measures for the right and left knee extension.

Discussion

The F ratios for the comparison between groups for the eight dependent variables in the analysis of covariance indicated that all the F Values were significant at the .05 level of confidence. The experimental treatments must be responsible for the observed changes since there were no significant differences between the groups on the pretest measures except two. Even with those, the use of covariance compensated for the initial difference.

On the strength measures, the two experimental groups improved significantly over their pretest measures but they too were not statistically significantly different from each other. This outcome is not in agreement with previous studies. Moffroid and Whipple (27), for example, found the slow maximal group to be significantly different from the rapid maximal group. Otaghen (29) found the slow speed group to be significantly different from the control but not the fast speed group. On the other hand, Pipes and Wilmore (32) found that the high speed group demonstrated significantly greater strength gains than the low speed group.

Examination of the Power I and II measures for the right and left knee extensions indicates that the experimental groups were significantly different from the control group on the posttest power measures. The experimental groups showed significant improvement over their pretest measures, but they were also significantly different from each other. The fast speed group was significantly different from the slow speed group.

The findings of this investigation on the power measure are consistent with those in previous studies. The measurement of power in most of the previous studies were based on field tests such as the vertical jump. Hunter (14), Oteghen (29), Knight (16), and McKenzie (26), all reported that isokinetic groups were superior in the vertical jump to groups using other training methods. With regard to isokinetic training speeds, Hunter (14) found in his study "The effect of two isokinetic training programs

on vertical jump performance of male varsity college basketball players" that the fast speed and high repetition group was significantly better than the slow speed low repetition group. He concluded that the fast speed and high repetition training method was a more effective method of increasing vertical jump that the slow speed and low repetition training method. Lesmes, et al. (19) reported that the mean work output of their experimental subjects who trained at 180 degrees revolution per second increased significantly after training. From the results of the power measures, one may conclude that the fast speed of isokinetic training is more effective in improving power development than the slow speed.

An inspection of the endurance measures for the right and left knee extension revealed that the two experimental groups made larger gains over the pretest measure than the control group. Results also indicate that the fast speed group is significantly different from the slow speed group on the right and left knee extensions.

Previous studies support the outcome of this study on endurance. For example, Lemes (19) employed an isokinetic training program at 180 degrees revolution per second for seven weeks, four times a week. He found that during the 60 second fatigue test, the subjects performed significantly more work than they did before training. Moffroid (27) also found that the rapid maximal exercise group showed a larger increase in muscular endurance than the slow maximal exercise group. Based on the

results of this study, the fast speed isokinetic training is a more effective way of increasing muscular endurance.

Conclusions

Within the scope and limitations of this study, the results have suggested the following conclusions:

1. The isokinetic training method is effective, in developing muscular strength, power and endurance.
2. The isokinetic fast speed is a better method of training to bring about power development than slow speed.
3. The isokinetic fast speed training is a more effective way of increasing muscular endurance than the slow speed training.

Recommendations

The results, conclusions and limitations of this study raise a number of questions with regard to possible future studies on similar and closely related variables.

1. Would comparable results be obtained from an identical study if the treatment groups were larger?
2. Would a longer training period of about 14 weeks have brought about a significant difference between the fast and the slow speed groups on the strength measure?
3. What would be the outcome if the dominant and nondominant legs were compared on all the dependent variables?

4. Would identical conclusions be arrived at if the training period per set were doubled from twenty to forty seconds?
5. Which of the two power measures is a more accurate way of determining power? Would there be a high correlation between the two power measures?

APPENDIX I

INFORMED CONSENT FORM

As part of the requirements of a Master's Degree, I will be conducting a research study to be submitted to the Department of Physical Education and Recreation. The title of the study is "EFFECTS OF TWO SPEEDS OF ISOKINETIC TRAINING ON STRENGTH, POWER AND MUSCULAR ENDURANCE." The basic outline for the study is as follows: College females in the Figure Improvement classes and Bowling Classes will be used as subjects. Volunteers from a randomly selected group of students from the Figure Improvement class will serve as the experimental groups and they will be randomly assigned after matching based on pretest strength scores to two experimental groups: the Isokinetic Slow Speed and the Isokinetic Fast Speed groups. The slow speed group will train at slow speed and the fast speed group will train at fast speed on the Orthotron. The control group from the Bowling class will receive no training. The three groups will be tested at the beginning and at the end of the study period.

The National Research Act of 1974 requires that any person participating in a research investigation must give informed consent prior to participation in the research project.

Please complete the section below if you consent to be a subject in this study.

I agree to be a subject in this research study and as a subject I understand that I can withdraw my consent and discontinue participation in this study any time.

Permission give by: (Name)_____

on this day _____ month of _____ 1979.

Signature_____

You are free to ask me any questions concerning the study.

Thanks for your cooperation.

Kunle Adeyanju
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Western Kentucky University
Bowling Green, Kentucky

APPENDIX II

Pretest Strength Measure (Ft-lbs)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	107	116	121	86	126	117
2	100	106	109	103	100	121
3	68	111	110	72	94	86
4	114	108	108	106	102	108
5	68	78	89	66	74	96
6	96	118	73	86	106	76
7	101	116	117	99	112	106
8	127	102	96	114	126	106
9	106	100	94	84	93	80
10	78	81	103	66	72	110

APPENDIX III

Pretest Power I Measure (Ft-lbs/sq.inch)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	168	150	141	158	150	121
2	115	115	130	130	121	166
3	119	111	111	122	82	118
4	175	169	105	130	138	133
5	148	70	95	130	83	107
6	175	157	131	131	115	125
7	160	145	141	153	169	133
8	162	140	120	168	142	141
9	132	106	75	114	119	105
10	129	141	125	152	160	151

APPENDIX IV

Pretest Power II Measure (Ft-lbs/sq.inch)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	225	230	210	210	225	190
2	168	170	200	180	160	220
3	165	170	180	180	125	180
4	245	230	180	180	195	200
5	190	120	150	165	120	165
6	230	180	195	180	225	165
7	200	180	210	180	230	195
8	238	200	180	246	210	200
9	193	150	130	165	165	160
10	185	160	180	195	160	220

APPENDIX V

Pretest Endurance Measure (# of Repetition)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	15	26	22	15	24	25
2	26	20	17	17	19	26
3	21	23	32	21	21	29
4	18	27	19	14	23	17
5	15	18	30	10	24	31
6	19	14	19	19	13	16
7	18	14	18	12	17	15
8	27	16	17	20	21	21
9	22	15	16	17	14	11
10	12	16	20	13	15	24

APPENDIX VI

Posttest Strength Measure (Ft-lbs)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	95	144	128	96	134	130
2	92	99	114	98	110	118
3	75	126	115	76	96	102
4	118	118	118	108	115	121
5	66	88	108	70	94	98
6	97	126	109	88	121	90
7	94	123	121	96	116	114
8	118	126	100	114	112	107
9	105	108	105	90	98	94
10	68	94	104	63	98	117

APPENDIX VII

Posttest Power I Measure (Ft-lbs/sq.inch)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	179	180	215	163	166	168
2	120	166	246	141	129	214
3	131	159	127	126	125	143
4	164	190	228	142	203	214
5	150	131	173	133	119	167
6	165	200	161	133	171	187
7	161	206	181	145	177	175
8	183	188	212	176	152	188
9	133	133	190	116	140	175
10	131	187	212	158	169	213

APPENDIX VIII

Posttest Power II Measure (Ft-lbs/sq.inch)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	230	250	280	220	246	230
2	172	225	320	200	180	270
3	175	220	225	166	165	210
4	260	250	300	200	255	275
5	190	170	240	162	180	210
6	220	250	265	180	255	240
7	210	255	250	180	260	240
8	240	240	320	245	220	270
9	190	190	265	162	180	220
10	190	210	290	205	195	275

APPENDIX IX

Posttest Endurance Measure (# of Repetition)

	Right Knee Extension			Left Knee Extension		
	Control	Slow Speed	Fast Speed	Control	Slow Speed	Fast Speed
1	18	27	30	16	28	29
2	19	11	34	23	23	35
3	17	22	38	23	22	41
4	24	24	26	18	26	26
5	17	23	39	12	21	36
6	21	16	32	19	16	27
7	16	18	40	15	20	30
8	29	11	19	12	23	26
9	21	19	34	18	18	32
10	11	20	32	13	23	28

BIBLIOBRAPHY

(1) Astrand, Per-Olof and Rodahl, K. Textbook of Work Physiology. Toyko: McGraw-Hill, Kogakusha, Ltd.

(2) Berger, R.A. "Comparison Between Resistance Load and Strength Improvement." Research Quarterly Vol. 36:141, 1965.

(3) Campbell, D. "Variations in Methods of Exercise and Rest Period Interval Upon Strength and Endurance." (Unpublished M.S. Thesis) Completed Research Vol. 17, 1974.

(4) Capen, E.K. "The Effect of Systematic Weight Training on Power, Strength, and Endurance." Research Quarterly Vol. 21:83, 1950.

(5) Clarke, H.H. Application of Measurement to Health and Physical Education. Prentice Hall, Inc. Englewood Cliffs, New Jersey, 1967.

(6) Chu, D.A. "Comparison of Selected Electromyographic Data Under Isokinetic and Isotonic Stress Loads." Unpublished Ph.D Abstract, Stanford University, 1976.

(7) Closs, E. Lee. "Isokinetic Measurement of Strength in Black and White University Women." Abstract of Research Papers AAHPER Convention, March, 1977.

(8) Coleman, A.E. "Comparison of Weekly Strength Changes Following Isometric and Isotonic Training."

(9) Coplin, T.H. "Isokinetic Exercise: Clinical Usage." Journal of Nata 6:222, 1971.

(10) Edington, D. W. and Edgerton, V.R. The Biology of Physical Activity. Houghton Mifflin Co. Boston, 1976.

(11) Gettman, L.R. and J. Ayers. "Aerobic Changes Through Ten Weeks of Slow and Fast Speed Isokinetic Training." Completed Research Abstract Vol. 17, 1974.

(12) Girardi, G.J. "A Comparison of Isokinetic Exercises with Isometric and Isotonic Exercises in the Development of Muscular Strength and Endurance." Unpublished Ph.D Thesis, Indiana, 1974.

(13) Hislop, H.J. and Perrine, J.J. "The Isokinetic Concept of Exercise." Physical Therapy 47:114, 1967

(14) Hunter, R.E. "The Effects of Two Isokinetic Training Programs on the Vertical Jump Performance of Male Varsity College Basketball Players." Complete Research Vol. 19 No. 733, 1977.

(15) Katch, F.I. "Neuromuscular Specification of Isokinetic Bench Press Training in Women." Medicine and Science in Sports 7 (1): 1977.

(16) Knight, Julia P. "A Comparison of Selected Isokinetic Training Velocities on the Development of Muscular Power in College Women." Unpublished M.S. Thesis, Old Dominion University, Norfolk, Virginia, 1974.

(17) Kouskin, A.N. "Isokinetic Exercises." Theory and Practice of Physical Culture and Sport. USSR Abstract.

(18) Lennos, J.W. "The Effect of Isokinetic Exercise on Quadriceps Strength and Electromyographical Activity in Vastus Medialis Muscles." Completed Research in HPER Vol. 16, 1974. No. T 515

(19) Lesmes, G.R. and E.F. Coyle. "Muscle Strength and Power Changes During Maximal Isokinetic Training." Medicine and Science in Sports. Vol. 10 No.4 pp. 266-269, 1978.

(20) Logan, Gene A. "Isometric Contraction." Doctorate Thesis. University of Southern California, Los Angeles, 1961.

(21) Mayhew, J. and Gross, P. "Body Composition Changes in Young Women with High Resistance Weight Training." Research Quarterly 45, 1974, 433.

(22) Mathews, D.K. and Fox, E.L. The Physiological Basis of Physical Education and Athletics. W.B. Saunders Company, Philadelphia, 1976.

(23) McCaffery, W.B. and Horvath, S.M. "Specificity of Exercise and Specificity of Training: A Subcellular Review." Research Quarterly. Vol. 48, No. 2, 1976, 358.

(24) McGraw, Lynn W. and Burnham, S. "Resistance Exercise in the Development of Muscular Strength and Endurance," The Research Quarterly 37 (March, 1966) 79.

(25) McDuffie, R.A. "The Effects of Isotonic, Isometric and Isokinetic Exercise Training Programs on Times of Individual Running 100 Yards." Unpublished M.A. Thesis. Completed Research Vol. 17, 1974.

(26) McKenzie, Jean "Effects of Isokinetic Training on the Vertical Jump Performance of Female Volleyball Players." Completed Research. Vol. 19, 1977, No. 736.

(27) Moffroid, M.T. and Whipple, R.H. "Specificity of Speed of Exercise." Completed M.A. Thesis, New York University, New York.

(28) Moffroid, M.T., Whipple, R.H., Hofkosh, J., Loman, E., and Thistle, H., "A Study of Isokinetic Exercises." Physical Therapy 49, 1969, 735.

(29) Oteghen, S.L.V. "Two Speeds of Isokinetic Exercise and Vertical Jump Performance of Women." Research Quarterly 46, 1975. 78.

(30) Perrine, J.J. "Isokinetic Exercise and the Mechanical Energy Potential of Muscle." Journal of Health, Physical Education and Recreation 44; May, 1968, 40.

(31) Pipes, T.V. " Variable Resistance Vs. Constant Resistance Strength Training in Adult Males." Abstract of Research Papers, AAHPER Convention March, 1977.

(32) Pipes, R.V. and Wilmore, J.H. "Isokinetic Vs. Isotonic Strength Training in Adult Men." Medicine and Science in Sport Vol. 7 No. 4 1974, 262.

(33) Price, S. " The Effects of Weight Training on Strength, Endurance and Body Composition in College Women." Abstract: Research Papers AAHPER Convention, Atlantic City, New Jersey, March, 1975.

(34) Rarick, O.L. and Larson, G.T. "Observations of Frequency and Intensity of Isokinetic Muscular Effort in Developing Static Strength in Pre-Pubescent Males." The Research Quarterly 29, October, 1958, 333.

(35) Rosentswieg, J., Hinson, M. "Comparative Muscle Action Potential Values of Isometric, Isotonic and Isokinetic Contraction." Abstract: Research Papers AAHPER Houston, Texas, 1974.

(36) Rosentswieg, J., Hinson, M., and Ridgway, M. "An Electromyographic Comparison of an Isokinetic Bench Press Performed at Three Speeds." The Research Quarterly 32, 1961. 88.

(37) Sharkey, B.J. Physiology and Physical Activities Harper and Row, Publishers, New York, 1975.

(38) Staheli, W.K. "A Comparison of the Effects of Isokinetic and Isotonic Exercise Methods on Leg Strength, Vertical Jump and Thigh Circumference." Abstract: Research Papers AAHPER Convention Atlantic City, New Jersey, March, 1975.

(39) Steel, R.G.D. and Torrie, J.H. Principles and Procedures of Statistics McGraw-Hill Book Co. Inc. New York, N.Y., 1960.

(40) Wagner, Lois E. "The Effect of Isokinetic Exercise on the Transfer of Strength to the Collateral Arm." Unpublished Thesis. M. Ed. East Stroudsburg State College, 1970.

(41) Wilmore, H.J. Athletic Training and Physical Fitness Physiological Principles and Practices of the Conditioning Process. Allyn and Bacon, Inc. Boston, 1977.

(42) Wilmore, H.J. "Alteration in Strength, Body Composition and Anthropometric Measurements Consequent to Ten Weeks Weight Training Program." Medicine and Science in Sport 6:1974: 133.

(43) Wilmore, H. J. "Body Composition and Strength Development." Journal of Physical Education and Recreation 46 (1) 1975: 38

(44) Wilmore, J.H. Exercise and Sport Science Reviews Edited by Wilmore. Vol. 1, 1973.

(45) Wachtlova, M. and Hermansen, I. "Capillary Density of Skeletal Muscle in Well Trained and Untrained Men." Journal of Applied Physiology 30: 1971, 860.

(46) Lumex Isokinetic Systems, Lumex, Inc. Cybex Division. 100 Spence Street, Bay Shore ,New York, 11706.

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