Effects of Isokinetic and Isotonic Muscle Training on Vertical Jumping Ability and Maximum Power Output as a Result of Four and Six Week Training Programs

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This study compared the effects of two training programs, one isotonic and the other isokinetic, on vertical jumping (VJ) ability and maximum power output (MPO) over periods of four and six weeks. Fifty-five male subjects volunteered with 50 completing the six week program. Subjects were randomly assigned to groups and treatments randomly assigned to the three groups. The isokinetic (ISOK) group consisted of N=17, isotonic (ISOT) N=16, and control (CONT) N=17, subjects. Subjects trained three times per week for six weeks, with training programs consisting of three sets of ten repetitions per workout. Testing was performed initially (T1) at four weeks (T2) and six weeks (T3). Test battery consisted of Margaria-Kalamen power test and jump and reach test for VJ. An ANCOVA was used to determine significance. When significance was noted a Scheffe Post Hoc test was performed. Statistical analysis demonstrated significant ($p < .05$) differences for MPO with ISOK T1-T3 and T2-T3, ISOT T1-T3 and T2-T3. Significance ($p < .05$) occurred for VJ only with the ISOK group T1-T3 and T2-T3. It was concluded that the training programs used produced significant improvement in MPO for both experimental (ISOK & ISOT) groups, but only ISOK training produced significant improvement in VJ with six weeks training.

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Without the support and love of my wife, Michele, my graduate work would never have become a reality. Her sacrifices and willingness to give in my behalf go beyond the limits one hopes of love and marriage. She is my friend, confidante, and love of my life.

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CHAPTER I

INTRODUCTION

Coaches, athletes and physical educators usually seek those training methods that will maximize athletic performance. Developing training methods means defining the skills necessary to specific activities.

Several athletic activities such as basketball, football, high jumping, and volleyball depend upon vertical jumping ability for high level performance (Blattner & Noble, 1979; Harris, 1959). Maximizing vertical jumping ability, therefore, has a profound effect upon performance. The athlete who possesses a greater and more powerful vertical jump has an advantage over the athlete with a lesser vertical jump.

Training methods vary according to purpose of the training program (Berger, 1962; 1965; Blattner & Noble, 1979, Eisenman, 1978; Van Oteghen, 1975). The types of training methods can be categorized into the following: isotonic, isometric, isokinetic, and plyometric. Within each of the four methods programs have been developed for strength (Berger, 1965; DeLorme, 1945), endurance (Van Oteghen, 1975; Nagel & Irwin, 1960), and power (Blattner & Noble, 1979); Hickson, 1980; Coyle, Reiring, Rotkis, Cote, Ruby, Lee, & Wilmore, 1981).

The majority of training studies are approximately eight weeks long (Blattner & Noble, 1979; Hickson, 1980) or longer, extending to ten to twelve weeks (Berger, 1963; Pipes & Wilmore, 1976). Few reports

have been done with shorter training programs. Few investigations compare the effects of isotonic training to isokinetic training with respect to vertical jumping performance or power output measurements.

Statement of the Problem

The purpose of this study was to compare the effects of two training programs, one isotonic and the other isokinetic, on vertical jumping ability and maximum power output over periods of four and six weeks.

Need for the Study

The results of strength training methods have been well documented throughout the literature (Berger, 1965; Blattner & Noble, 1979; Eisenman, 1978, Van Oteghen, 1975). These studies represent a number of separate training concepts. Berger (1965) utilized the isotonic method of training to accomplish the necessary increases in strength. Blattner and Noble (1979) took advantage of the plyometric mode to elicit an increase in vertical jump performance. Eisenman (1978) and Van Oteghen (1975) trained subjects isokinetically to demonstrate improvements in strength and vertical jumping ability.

The isokinetic concept of strength training appears to hold the most promise in vertical jump training. Because it provides maximum resistance with constant speed throughout an entire range of motion, isokinetics may prove superior to more traditional training programs. The incidence of injury in isokinetic training is also significantly lower (Pipes & Wilmore, 1976). The advantages of isokinetic training

have been advanced into the commercial arena. Results reported by equipment manufacturers appear to have low correlations to reported studies in the literature.

Definitions of Terms

Isokinetic: Isokinetic contraction is a contraction in which the tension developed by the muscle while shortening is maximal over the full range of motion and the speed of contraction is constant.

Isometric: Isometric contraction is a contraction in which tension is developed, but the length of the muscle does not change.

Isotonic: Isotonic (or dynamic) contraction is a contraction in which the muscle shortens (concentric) or lengthens (eccentric) with varying tension while moving a constant resistance.

Plyometric: Plyometric contraction is a contraction in which the muscle is in the preset stretch condition prior to explosive contraction.

Power: Power is performance of work expressed per unit of time.

$$\text{POWER} = \frac{\text{FORCE} \times \text{DISTANCE}}{\text{TIME}}$$

Strength: Strength is the force that a muscle or muscle group can exert against a resistance in one maximal effort.

Delimitations

The following were delimitations of this study:

1. The study consisted of males, between the ages of 18 and 28 years, attending the University of Wisconsin - LaCrosse during the second semester of the 1981-1982 school year.
2. All subjects were volunteers.

Limitations

The following were limitations of the study:

1. The subjects in the isokinetic group were instructed to make each contraction a maximal contraction. The investigator had no way of determining maximal contractions.
2. Dropouts for this study were defined as those who missed more than four training sessions.
3. Subjects were encouraged to maintain their normal dietary patterns during the term of the study.
4. Subjects were encouraged to maintain their normal exercise habits.
5. Subjects were encouraged to refrain from any leg strength training other than that which was a part of this study.

Assumptions

The following were assumptions of the study:

1. All subjects within each experimental group received the same amount of work with regard to time, intensity, and duration.
2. All subjects within the control group refrained from all additional training which might affect vertical jump or maximum power output.

Hypotheses

The following were tested for maximum power output:

1. There would be no significant difference in maximum power output as a result of four weeks isokinetic training.

2. There would be no significant difference in maximum power output as a result of six weeks isokinetic training.

3. There would be no significant difference in maximum power output between four and six weeks of isokinetic training.

4. There would be no significant difference in maximum power output as a result of four weeks isotonic training.

5. There would be no significant difference in maximum power output as a result of six weeks isotonic training.

6. There would be no significant difference in maximum power output between four and six weeks of isotonic training.

7. There would be no significant difference in maximum power output between isokinetic and isotonic groups with four weeks training.

8. There would be no significant difference in maximum power output between isokinetic and isotonic groups with six weeks training.

The following were tested for vertical jumping performance:

9. There would be no significant difference in vertical jumping performance as a result of four weeks isokinetic training.

10. There would be no significant difference in vertical jumping performance as a result of six weeks isokinetic training.

11. There would be no significant difference in vertical jumping performance between four and six weeks of isokinetic training.

12. There would be no significant difference in vertical jumping performance between four and six weeks of isotonic training.

13. There would be no significant difference in vertical jumping performance as a result of six weeks isotonic training.

14. There would be no significant difference in vertical jumping performance between four and six weeks of isotonic training.

15. There would be no significant difference in vertical jumping performance between isokinetic and isotonic groups with four weeks training.

16. There would be no significant difference in vertical jumping performance between isokinetic and isotonic groups with six weeks training.

CHAPTER II

REVIEW OF RELATED LITERATURE

INTRODUCTION

Vertical jumping ability is important in the performance of numerous athletic events. Over the years coaches, trainers, and physical educators have used a variety of training methods to improve vertical jumping ability. Berger (1962) began some of the initial studies of strength and effectiveness of different types of training regimens. Berger found increases in dynamic strength significantly exceeded those of static strength. In 1979 Blattner and Noble found increases in vertical jumping ability to be significant with both isokinetic and plyometric strengthening programs. Other authors have demonstrated similar results with various types of isokinetic training programs (Campbell, Bonen, Kirby, & Beleastro, 1979; Pipes & Wilmore, 1976; Scoles, 1978; Thorstensson, Sjodin, & Karlsson, 1975; Van Oteghen, 1975; Wilmore, 1979). This review of related literature will be divided into: (1) types of strength training and (2) isotonic versus isokinetic training methods.

Types of Strength Training

The review of related literature pertaining to types of strength training will be divided into four sections: (1) isotonic,

(2) isokinetic, (3) isometric, and (4) plyometric. The major emphases will be isotonic and isokinetic since these two types of training were used in this study.

Isotonic

Isotonic muscle contraction refers to a muscle contraction in which the resistance remains at a constant level during the range of motion (Thistle, Hislop, Moffroid, & Loman, 1967). During the contraction the muscle either shortens or lengthens. Isotonic contractions, therefore, may be either concentric or eccentric (DeVries, 1980). The resistance to the muscle is not constant, however, because of the effects of the lever system through which it must pass. The load on the muscle is greatest at the extremes of the range of motion, either at full extension of flexion. In effect, the tension demand placed on the muscle is maximum only during a small portion of the range of motion (Hislop & Perrine, 1967).

In spite of the small range of maximal resistance, the effects of isotonic strength training programs have been well documented. Berger (1962) trained college-aged men with free weights using the bench press. He reported on that training which took place three times per week. Variations in the training programs involved one set with two repetitions, two sets with six repetitions, and three sets with ten repetitions. The latter produced the best results for strength and vertical jumping ability. The groups that trained dynamically, or isotonically, improved significantly more in vertical jump that the groups that trained statically or trained strictly by jumping vertically. Berger

(1965) found that groups training twice weekly with 66, 80, and 90 percent of maximum and six repetitions, demonstrated significant increases in strength over control subjects.

McGovern & Luscombe (1953), using a modification of DeLorme's progressive resistance method, exercised young men using isotonic methods. The modifications involved two sets of ten repetitions using 100 percent of the 10 RM maximum. These two sets were prior to and after one set of ten repetitions with 75 percent of the subject's 10 RM maximum. Their results, using leg extension as the training exercise, demonstrated significant improvements in strength as a result of training five days a week for three weeks.

In 1976 Pipes & Wilmore showed a .4 inch increase in vertical jumping ability as a result of an eight-week training program. This study used men aged 20 to 38 years old who exercised three days per week. Although the increases in strength and vertical jumping ability were significant, the increases in the isokinetically trained group were of much greater magnitude and equally as significant.

Isokinetic

Isokinetic muscle contraction refers to a muscle contraction in which the speed remains constant throughout the range of motion (Thistle, et al., 1967). In the isokinetic method of training, resistance is in direct ratio to the force applied so that maximal force may be maintained throughout the entire range of motion. There is an inverse relationship between speed and tension developed using isokinetics. At lower speeds the force generated is high, but as the speed increases the force decreases (DeVries, 1980).

The isokinetic method of training has several advantages over more traditional methods of training. Muscles work at maximum force throughout the entire range of motion for each repetition, thereby providing a greater training stimulus. Hinson and Rosentswieg (1973), using electromyographic studies with college women, found the action potential produced with isokinetic contraction to be significantly greater than either isotonic or isometric. They state,

> On the basis of muscle action potential produced, the isokinetic method of contraction should be favored over the isotonic method since the isokinetic method provides for the full range of motion and produces greater muscle action potential than the isotonic method for a greater number of subjects.

Pipes & Wilmore (1976) also found the isokinetic training procedure superior to isotonic for affecting changes in strength and motor performance. They found a significant difference in both low and high speed isokinetic groups from the isotonic and control groups. As a result of an eight week training program, the isokinetically trained men increased vertical jumping performance by a mean of 1.1 inches in the low-speed group and 0.9 inches in the high-speed group. Blattner & Noble (1979), working with college males in an eight-week program, reported mean increases of 1.94 inches with the isokinetically trained group. These subjects trained three times a week with each training period consisting of three sets of ten repetitions each.

Isokinetics may be performed at a variety of speeds with maximal resistance. By controlling velocity, the neuromuscular variability within the skeletal lever system's ability to work is negated. Pipes (1977) in a review article said that in almost any human movement the greatest work is performed at the initial stage of movement. Therefore,

the resistance will be moving through the range of motion at an accelerating rate, thereby diminishing the muscle's ability to perform work against the resistance. One way of negating this factor is controlling the speed at which the limb contracts. The best way to improve the speed of a muscle is to strengthen it through high resistance isokinetic exercise at increased speed (Counsilman, 1976).

It has been shown that the initial loss in strength due to muscle soreness with isotonic training is virtually eliminated with the isokinetic method (Pipes & Wilmore, 1976; Talag, 1973; Thistle, et al., 1967). Talag (1973), using both men and women subjects, measured residual muscle soreness resulting from concentric, eccentric, and static contractions. The results showed that eccentric contractions produced greater residual muscle soreness than concentric and static contractions. Peak muscle soreness occurred 48 hours after exercise. Muscular strength decreased appreciably following eccentric contraction, and remained lower throughout the duration of muscular soreness. No significant differences were found in strength between concentric and static contractions. Consistent with the results of Talag Pipes & Wilmore (1976) reported an initial loss of strength with the isotonic group but observed no loss of strength with either of the isokinetic groups. Unlike the isotonic groups, the isokinetic groups reported no significant muscle soreness as a result of the training. The elimination of residual muscle soreness may occur because isokinetic resistance procedures employ only concentric contractions with little or no resistance during the recovery phase.

Isometric

Isometric exercise occurs when the resistance acting on the

skeletal lever is of sufficient magnitude to prevent motion and change in the length of the muscle (Hislop & Perrine, 1976). The relatively large resistance permits the muscle to develop maximum loading, but in only one position. As a result, no physical work is performed. Although resistance can be maximum, the strength gains have been found to be specific to within a small range of the joint angle exercised (Berger, 1963; Gardner, 1963).

Gardner (1963) worked with 60 male subjects in a six-week training program, three times a week. Training was performed on the preferred leg for six seconds at 2/3 of maximum tension. Although the subjects were tested at three specific angles (115°, 135°, 155°), each subject trained at only one. Gardner reported that on the exercised limb no significant strength gains were reported at angles other than the training angle. Berger (1963a) reported results on college males. The group training isometrically produced results significantly less than those training dynamically (isotonic) three times a week. The isometric group's results were significantly greater in strength improvement than the isotonic group which trained two times a week.

Recently, the strength gains have been found to occur within 20° of the training joint angle (Knapik, Ramos, & Wright, 1980). The authors trained 12 subjects (6 male, 6 female) using the elbow extensors. Training was at 90° with testing at three angles (70°, 90°, 110°). The results showed significant improvement at all the testing angles, proof of an effective training program covering 40° of the range of motion.

The effects of isometric training on vertical jumping ability have been less dramatic than with other methods of training. Berger (1963b)

reported results with college males. Although the isometric group showed an increase of .33 inches, this increase was not significant. In his study the only groups which showed significant increases were those which trained isotonically. Ball, Rich, & Wallis (1964) trained college men three times a week for six weeks. The experimental group showed a dramatic 17.3 percent increase in strength, but failed to demonstrate a concomitant increase in vertical jumping ability. Although useful in improving strength, isometrics appear to be less effective in improving vertical jumping ability.

Plyometric

The plyometric concept of training applies the specificity principle regarding the preset stretch condition of the muscle prior to explosive contraction (Wilt, 1975). Wilt in a review article pointed out the preset stretch condition is achieved by preceding the concentric contraction with an eccentric contraction in depth jumping. The plyometric concept involves use of the stretch reflex for greater concentric contraction. The muscle or muscle group is stretched to maximum length prior to the explosive contraction. According to Blattner & Noble (1979), recent studies involving plyometric training to improve vertical jumping performance have produced contradictory results. They pointed out interstudy differences relating to length, intensities, jumping heights, and sessions per week in the studies of Herman (1976), and Scoles (1978).

Depth jumping has been the major training mode using the plyometric principle. This involves jumping from a height to the floor and then springing upward vertically as rapidly and as high as possible. The height of the descent and the weight, if any, which the subject carries

are the manipulative variables in depth jumping. Although depth jumping has been shown to increase vertical jumping ability, results are not significantly greater than other types of training produce (Blatter & Noble, 1979).

Isotonic vs. Isokinetic Training

Strength is generally recognized as a major component of successful competition in most sports. All athletes need strength in varying degrees. Only in recent decades has strength training been given serious attention by coaches and trainers. The debate over which form of training is the most productive continues; each type of training method has specific application determined by the sport or skills involved.

The training methodologies will be limited now to isokinetic and isotonic comparisons. The advantage of isokinetics over isotonics is the ability of the muscle to work maximally throughout the entire range of motion. The effectiveness of isokinetics in improving vertical jumping performances has been demonstrated in several studies (Blattner & Noble, 1979; Eisenman, 1978; Van Oteghen, 1975). Blattner & Noble (1979) in their review of literature reported on the effectiveness of isokinetics as demonstrated by Hunter (1976) and Testone (1972). Blattner & Noble found a significant increase in a vertical jump of 1.9 inches following an eight-week, three-day-a-week isokinetic training program.

Vertical jumping improvements as a result of both isokinetic and isotonic programs have been reported as great as eight to twelve inches in a 1955 Sports College News report (Eisenman, 1978). Most researchers have found improvements from 0.7 cm (Bangerter, 1968) to 3.2 inches (Ness from Eisenman, 1978). Bangerter (1968), using male subjects training

three times a week for eight weeks with one set of eight to twelve repetitions maximum method, produced only minimal gains with isotonic training of hip and knee extensor muscles.

Strength and speed are major factors often studied in relationship to vertical jumping ability. Eisenman (1978) reported significant increases in both strength and vertical jumping performance. Working with female subjects, the author reported a mean increase of 0.8 inches in vertical jumping performance. Although the strength gains were reported as significant, they were not proportional to gains in jumping performance. A low correlation between strength and vertical jumping improvements was also reported using isokinetic training at several speeds (Van Oteghen, 1975). In training college volleyball players from four universities over an eight-week training program, Van Oteghen found results similar to those reported by Eisenman. The high speed isokinetic group was the exception. This group produced significant increases in vertical jumping without the accompanying increases in strength. McClements (1966), working with college men training isotonically, also attained a low correlation ($r=.25$) between strength gains and vertical jumping performance.

It appears there are no significant differences between men and women in response to progressive resistance training (Kearney, 1978). Based upon Kearney's review of the literature, we can accept the results in the literature at face value without making adjustments with regard to sex.

The speed at which an exercise is performed is an important criterion for determining the quality of muscle development. In the past, little attention was paid to this aspect of exercise; the mistaken conclusion was that whenever a muscle was made stronger, it was also made faster (Counsilman, 1976). A program of heavy resistance, low repetition exercises performed at slow and constant speed often impairs the explosiveness of the muscles (Counsilman, 1976). Van Oteghen (1975), upon examining the effects of two speeds of isokinetic training, found that both groups showed significant increases in vertical jumping performance. Only the slow velocity training group had a significant increase in strength. Some speculated, however, that the eight-week training duration was too limiting to manifest a training response.

Contrary to the results of Van Oteghen, Pipes & Wilmore (1976) found that isokinetic training at high speeds effects significantly greater changes in muscular strength. More important, the increases in muscular strength came at speeds that are more typical of those found in athlete activities. Vertical jump was significantly correlated with peak torque at fast angular velocity (180°/sec), but not at a slow angular velocity of 30° second (Genuario & Dolgener, 1980). Significant increases in the Sargent jump were observed following a six-week, high speed, sprint training bicycle ergometer program (Thorstensson, et al., 1975).

Power

Of the components of physical fitness, anaerobic power is perhaps the least understood (Burke, 1978). Anaerobic power involves the ability to perform all-out work without the use of oxygen. Power is defined as the

rate of performing work expressed as a unit of time (Halling & Dooley, 1979; Mathews & Fox, 1976; Moffroid & Kusiak, 1975). Halling & Dooley (1979) define power as the product of strength and speed. The time it takes for muscles to develop force, the rate at which muscles contract and sustain a force throughout the range of motion, and the relationship of speed to force are all facets of power.

Moffroid & Whipple (1970) cite the importance of specificity of training, concluding that exercise is speed specific. Low speed and high load exercise produces greater increases in muscular force at all speeds of contraction at and below the training speed. Training, for an increase in power will also bring about an increase in strength. Strength and power are highly related.

Counsilman (1976) believes the results of isokinetic training at fast speed are apparent at the white muscle fiber level. The white fibers are made stronger and their proportional mass is increased. Fibers are able to create more tension and adapt to the stress of fast high-resistance exercise by becoming not only stronger, but faster.

A review of the literature concerning training and power is best understood with the concept of speed kept close at hand. Several authors have shown improvement in power output as a result of training programs (Coyle, et al., 1981; Lesmes, Costill, Coyle, & Fink, 1978). Coyle et al. (1981) used college-aged males who were physically active, but untrained, as subjects in a six-week training program. They trained three times a week for six weeks, using isokinetic knee extensions. Power, as measured by peak torque, was improved significantly in both the slow and fast isokinetic groups. The fast isokinetic group also showed an enlargement

in type II fibers. The authors suggest fiber hypertrophy to be a plausible mechanism for the improvement of the fast group; however, a neurological adaptation that enhances power at and below the training velocity cannot be excluded.

Lesmes, etal. (1978) worked with males in a seven week training program. Subjects trained four times a week, exercising two consecutive days and resting on the third. Speed of training was constant at 180°/sec with variation in length of six and thirty seconds per set. The data demonstrated significant improvements in power, as measured by peak torque, for both the six and thirty second training methods. The authors suggested that athletes train at speeds approximately or exceeding those used during the actual sport.

Most recent studies have evaluated power through isokinetic procedures, but some have evaluated power output through non-isokinetic measures. Sargeant, Hoinville, and Young (1981) measured maximum leg force and power output during short term anaerobic dynamic exercise performed on a bicycle ergometer. Subjects performed a series of twenty second maximum efforts at different crank velocities (range 23-171 rev/min). Maximum power output was a parabolic function, indicating that the velocity for greatest power output was 110 rev/min.

Testing Measurements

Power Testing

The methods of testing or measuring anaerobic power can be a prime factor in determining athletic success. Power is performance of work expressed per unit of time (Fox & Mathews, 1982). Margaria suggested an

excellent test of power, which has been modified by Kalamen: The modification results in greater power output than in Margaria's original test procedure (Fox & Mathews, 1982; Katch, & Katch, 1981). The Margaria-Kalamen requires that the subject stand six meters in front of a staircase. The subject runs up the stairs as rapidly as possible, three steps at a time. Switchmats which start and stop an electronic timer are placed at the third and ninth stairs. Power output is computed using the formula:

$$P = \frac{W \times D}{t}$$

in which P= Power, W= Weight, D=Vertical height between first and last test stairs, t= Time from first to last test stairs.

Although Burke (1978) contends that there are no widely accepted tests of anaerobic power, the above mentioned authors include the Margaria-Kalamen test in their books. Its usage appears to be widespread. Bhanot & Sidhu (1981) used Kansal, Verma, & Sidhu's (1981) modification of the Margaria-Kalamen test to evaluate the maximal anaerobic power in national level Indian athletes. Their data was not a training study, but a descriptive report of several sport athletes. They observed that field game players produced less maximum power than court game players. Volleyball players possessed the highest results above football, hockey and basketball players.

Vertical Jump Testing

The vertical jump test measurements have been based upon the laws of physical science. The vertical jump power test has been shown to produce a test - retest reliability of r=0.985 (Gary, Start, & Glencross, 1962a). In another study Gray, Start, & Glencross (1962b), using a

modification of the vertical power jump, reported on test - retest reliability and validity of several jump methods. The modification of the vertical power jump was not a modification of procedure but a modification within the calculations. They reported test - retest reliability for the squat jump r=.969, jump reach r=.973, and modified vertical power jump r=.977. The validity coefficients of the various jumps were reported as squat jump r=.840, jump reach r=.780, and modified vertical power jump r=.989. VanDalen (1940) demonstrated good test - retest correlations for the Sargent jump r=.812 and reach jump r=.781. It would appear that the vertical jump test has been shown to be a reliable and valid testing measure.

Summary

The literature supports claims for improvement of strength, power, and vertical jumping performance by both isokinetic and isotonic training programs. The magnitude of enhancement of these variables may be in the arena of isokinetics, but there seems to be relatively few studies which directly compare isokinetic to isotonic training programs. The question of which type of training is preferable, and what length of time is necessary, is still unanswered.

CHAPTER III

METHODS

The purpose of this study was to determine the differences in vertical jumping performance and maximum power output resulting from participation in a four or six-week training program of either isokinetic or isotonic exercises.

Subject Selection

Fifty-five healthy males were used as subjects for this study. The subjects were undergraduate students who attended the University of Wisconsin-LaCrosse during the spring semester of the 1981-82 academic year. The subjects were volunteers whose ages ranged from 18 to 28 years. They were randomly assigned to one of three groups. Each group was then randomly assigned to a treatment. Group I trained with isokinetics, Group II trained with isotonics, and Group III was used as a control. Subjects who were either injured during the training period or missed more than four (4) training sessions were dropped from the study.

Testing Procedures

Prior to beginning the study all subjects were asked to complete and sign consent forms for both the testing and the training programs (See Appendix B). All subjects underwent an orientation session which reviewed and familiarized them with both the testing procedures and the operation of equipment involved. Each experimental group was allowed one week (three

sessions) of training prior to the initial testing. This was planned to allow practice and further familiarization with the equipment. The one-week pre-training sessions allowed the isokinetic group to practice using the Pro Jumper machine under supervision to ensure safe operation of the equipment. The isotonic group used the pre-training week to set the initial training weights and become familiar with the practice of lifting to failure during the third set. Failure was defined as the point at which addition repetitions could not be performed with proper technique.

Vertical Jump

Vertical jump performance was measured using the Sargent jump as outlined by Johnson and Nelson (1974). A tape measure was attached to the wall for taking vertical jumping measurements. Each subject stood with one side toward the wall, heels together. Keeping the heels on the floor, he reached up as high as possible; this height was noted. The subject, without moving his feet, jumped as high as possible and touched the measuring tape at the height of the jump; this jump mark was also noted. The distance between the reach height and jump mark measured to the nearest centimeter was the recorded score. Each subject was given six trials separated by a minimum of thirty seconds. The mean of trials three through six were used, as described by Blattner & Noble (1979), in order to minimize the learning effect and improve reliability and validity. The procedures outlined above were used for all vertical jump testing on the initial, four week, and six week tests.

Margaria-Kalamen Power Test

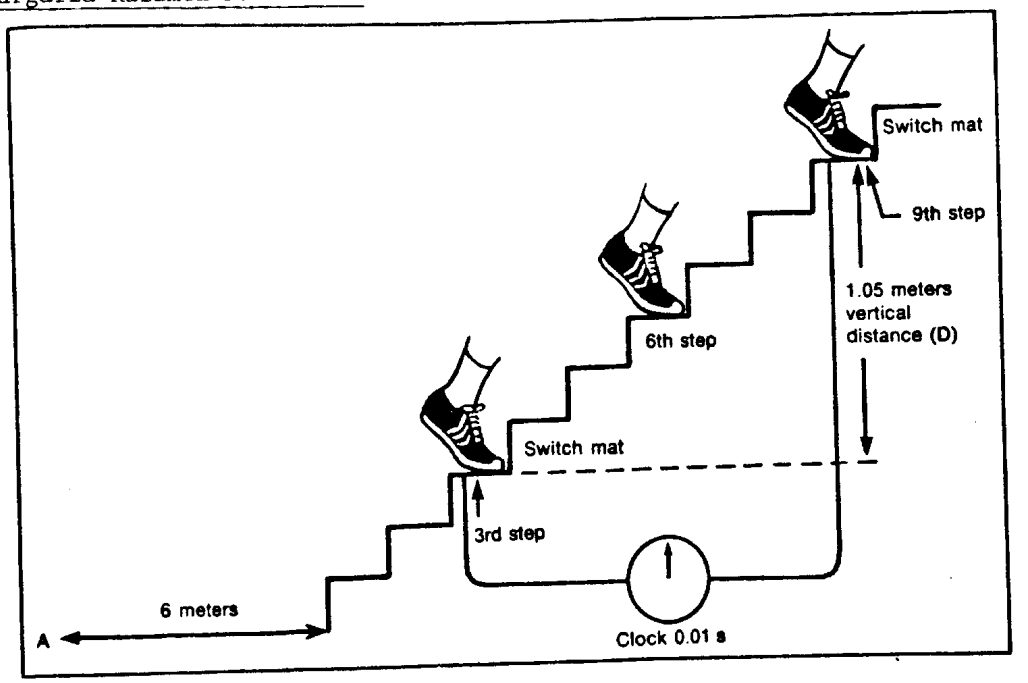

Figure 1 Margaria-Kalamen Power Test

The subjects stood six meters in front of a staircase. At their pleasure they ran up the stairs as rapidly as possible, taking three stairs at a time. A switchmat was placed on the third and the ninth stair. The switchmats were connected to a Dekan timer which recorded the time to a hundredth of a second. The timer was activated as the first switchmat was depressed and stopped as the subject stepped on the second switchmat (Fox & Mathews, 1982). Power output was computed using the formula:

$$P = \frac{W \times D}{t}$$

in which P= Power

W= Weight

D= Vertical height between first and last test stairs

t= Time from first to last test stairs

All measurements were metric and power was calculated in kilogram-meters/second (kg-m/sec).

Subjects were given an unlimited number of practice runs to establish the necessary footwork and confidence required to run up the steps rapidly. Once the subjects were sufficiently prepared, they were given a minimum of three trials. Subjects whose time continued to decrease were given additional trials until the time scores stabilized. The mean of the three fastest scores was recorded for statistical analysis. This procedure was used for all power scores for the initial, four week and six week tests.

Training Procedures

Subjects in both experimental groups trained three times a week for six weeks. All subjects performed a warm-up in preparation for each workout (See Appendix A).

The isokinetic group trained each session by performing three sets of ten repetitions per set. Subjects trained on the Pro Jumper leg press machine, manufactured by Isokinetic Sales Company, Independence, Missouri. Subjects were able to observe force exerted and were encouraged to execute each repetition as rapidly as possible and with maximum effort. Movement speed of the machine was set at the maximum allowable (58 feet/second). This speed converted to 728°/sec. Knees were bent to approximately 90° before each extension. Subjects rested a minimum of two minutes between sets during workout.

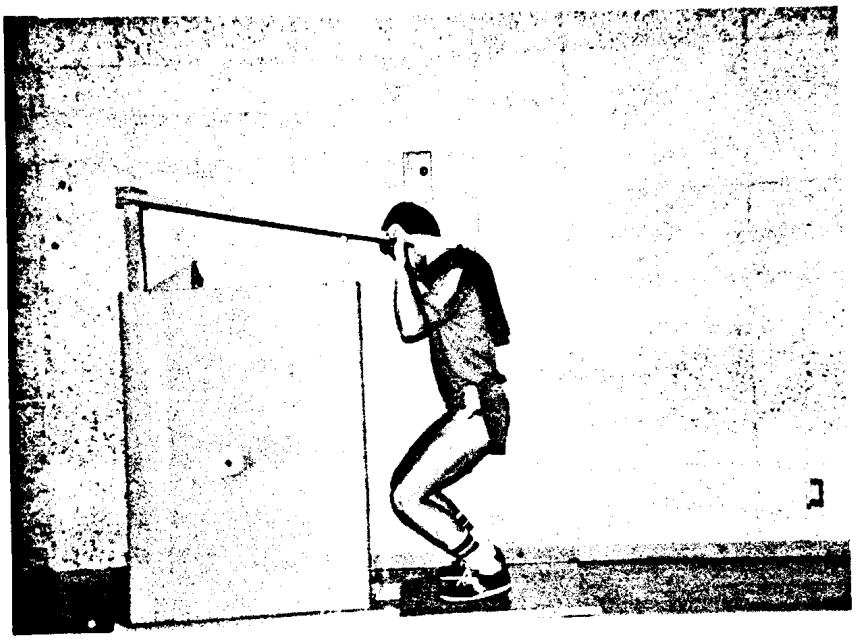

Figure 2 Pro Jumper Machine (Isokinetic)

The isotonic group trained each session by performing three sets of ten repetitions per set. The subjects in this group used Olympic weights and bar when performing leg squats. Knees were bent to approximately 90° before each extension. Subjects were instructed to lift to failure during the third set of each workout. Weight selection was determined during the pre-training week. During the training sessions ten pounds of weight were added as the failure point of the third set

exceeded ten repetitions. Failure was defined as the point at which addition repetitions could not be performed with proper technique.

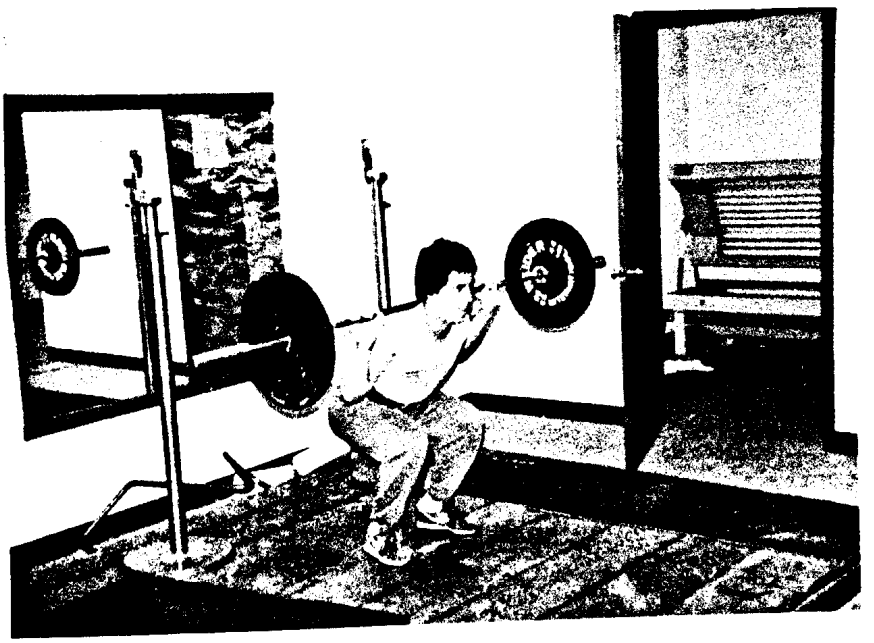

Figure 3 Olympic Weight Squats (Isotonic)

The control group was instructed to participate in normal activities. They were instructed not to participate in any weight training or strength training program.

Statistical Treatment of Data

Analysis of covariance was used to compare posttest scores with the effect of pretest difference removed. The least significant difference method of specific comparison among groups was used. Where significant differences were found to exist, a Scheffe post hoc was administered to locate the relationship which affected the significance.

CHAPTER IV

RESULTS AND DISCUSSION

Results

The information presented in Table 1 report the physical characteristics of the subjects in this study (N=50). Analysis of variance revealed no significant differences between the groups with respect to age, weight, and height. Subjects were a mean of 20.5 years of age, 76.9 kilograms, and 180.28 centimeters in height.

Table 1

Description of Subjects

Group		Age (Yrs.)	Weight (Kg.)	Height (Cm.)
I	isokinetic	20.4 (2.4)	78.3 (5.8)	108.78 (6.6)
II	isotonic	19.4 (1.3)	76.8 (10.3)	179.70 (9.0)
III	control	21.7 (2.6)	75.5 (5.6)	180.34 (4.7)
	total	20.5 (2.4)	76.9 (7.4)	180.28 (6.8)

Note. Numbers in parentheses indicate standard deviation.

Initially, the total number of subjects was 55. This was reduced by five at the end of the training period. The five dropouts occurred as a result of injury (two) and noncompliance (three). The injuries were a result of occurrences unrelated to the study training or testing. The three noncompliant subjects missed more than four training sessions. The

subjects within the two experimental groups attended 91.8 percent of the training sessions over the course of the study period. The isokinetic group (Group I) attended 91.1 percent and the isotonic group (Group II) attended 92.5 percent of the training sessions.

Results of the maximum power output as measured in kilogram-meters per second are presented in Table 2.

Table 2

Mean Maximum Power Output Results (kgm/sec)

Test	Isokinetic	Isotonic	Control
T1	158.33	161.02	149.75
T2	162.66	165.89	155.05*
T3	168.84*	171.59*	154.41

* significant $p < .05$

Table 3

Results of Scheffe Post Hoc Test
Maximum Power Output

Test	Isokinetic	Isotonic	Control
T1-T2	5.0202	5.9699	7.4941*
T1-T3	10.2064*	8.1707*	5.8094
T2-T3	29.5429*	28.1091*	.1071

* $F_{2,94}$ F=6.192 at .05 level

Analysis of covariance revealed several significant differences statistically. The isokinetic group (Group I) demonstrated two significant

differences. The training program showed a significant difference as a result of six weeks duration (T1-T3). A significant difference also occurred between four weeks (T2) and six weeks (T3). There was no significant improvement in maximum power output as a result of four weeks isokinetic training.

The isotonically trained group (Group II) demonstrated similar results to the isokinetic group. Group II showed a significant difference as a result of six weeks isotonic training. Another significant difference occurred between four weeks (T2) and six weeks (T3). Although under no experimental treatment, the control group (Group III) demonstrated the only significant increase from initial test to the four week test; but the control subjects actually showed a net nonsignificant decrease from four weeks to the final six week test.

All significant results were limited to within group differences. The ANCOVA revealed no differences among the groups (F=2.31).

Analysis of the vertical jumping performance data revealed a more complex set of results. Whereas the maximum power output data was limited to significant differences within groups, the analyzed data revealed significant differences within groups and among groups with regard to changes in vertical jumping performance.

Although the differences between groups were statistically significant, there was no clear pattern for practical use. The ANCOVA showed no statistical significance among groups for the same test. Table 4 shows the significant F and groups and tests involved as a result of the Scheffe Post Hoc tests.

Table 4

Results of Scheffe Post Hoc Test
Between Group Significances
Vertical Jumping

Group & Test	F*
G1T1 - G2T3	6.5765
G1T1 - G3T2	7.4974
G1T1 - G3T3	7.8003
G1T2 - G2T1	40.9441
G1T2 - G2T3	20.8633
G1T2 - G3T1	18.4608
G1T2 - G3T3	23.3011
G1T3 - G2T1	80.3475
G1T3 - G2T2	46.4445
G1T3 - G3T1	47.6278
G1T3 - G3T2	54.4207

* $F_{4,94}$ F=4.948 at .05 level

Table 4 shows the significant differences, but the practical application of such results to the experimental methods used in this study or to other training programs is limited.

The results of the ANCOVA as pictured in Table 5 show the results of within group analyses. The analysis of the data demonstrated fewer significant relationships in vertical jumping performance than noted

Table 5

Mean Vertical Jump Results (cm.)

Test	Isokinetic	Isotonic	Control
T1	55.17	52.87	54.01
T2	56.22	54.00	53.76
T3	57.56*	53.83	53.73

* significant p 7.05

Table 6

Results of Scheffe Post Hoc Test
Vertical Jump

Test	Isokinetic	Isotonic	Control
T1 - T2	4.1380	4.4809	.2263
T1 - T3	21.5194*	3.2544	.2814
T2 - T3	6.7843*	.0978	2.9992

* $F_{2,94}$ F=6.192 at .05 level

in the maximum power output testing. Only the isokinetic group (Group I) showed any significant improvement in vertical jumping performance as a result of the training program. The isokinetic group demonstrated a significant difference which existed between four weeks (T2) and six weeks (T3) of training. Although the increase of 1.12 cm by the isotonic group from initial (T1) to four weeks (T2) would appear great enough to be noteworthy, it proved to be not significant statistically at the .05 level. All significant increases in vertical jumping ability were demonstrated by the isokinetic group.

Discussion

The duration of the training period may explain the above results. The experimental period was shorter than that of most of the studies cited in the review of literature. Study, or training length, varied from eight weeks (Blattner & Noble, 1979; Pipes & Wilmore, 1976; and Van Oteghen, 1975) to one semester or sixteen weeks (Eisenman, 1978).

Maximum power output produced results which were significant for both experimental groups at six weeks and between four and six weeks. The significant increase found at the four week test in the control group seems to indicate some unexpected influence from an uncontrolled variable. Even though subjects were given unlimited trials prior to the three recorded trials, it appears that a learning effect occurred within the control group.

Given the fact that the power increases were significant at similar points for both experimental groups, the significance of the findings noted in the vertical jumping results are of particular interest. Within the groups the only significant increases were noted in the isokinetic training group. The lack of increase in vertical jump by the isotonic group coupled with increases in power output deserves further explanation.

Although strength was not measured directly in this study, the initial losses in strength reported by Talag (1973), Thistle, et al. (1967), and Wilmore (1975) may be related to the inability to increase vertical jump found in this study. Wilmore (1975) reported similar results to those found in this study. The increases in vertical jump were significant in the isokinetically trained group but were not demonstrated by the isotonic group.

Speed of training may provide an explanation of performance increases in the isokinetic group and absent in the isotonic group. Specificity of training suggests that the improvements should be greatest when tested with a procedure which most approximates the training procedure. The speed of the isokinetic training (728°/sec) more closely approximates the angular velocities in vertical jumping. Eckert (1968) found the joint angular velocities of the hip, knee, and ankle to be 642°/sec, 902°/sec, and 1,079°/sec respectively. The improvement of the isokinetic group and lack of significant differences demonstrated by the isotonic group might be explained by the isokinetic group's specificity of speed in the jump and reach test of vertical jump.

The six week increase of 2.39 cm found with the isokinetic group is consistent with the results of 2.03 cm reported by Eisenman (1978). Van Oteghen (1975) reported significant increases in both slow and fast isokinetic groups as a result of eight weeks of training. The results of the isokinetic group also compare favorably with the 2.7 cm (low speed) and 2.28 (high speed) isokinetic groups trained eight weeks by Pipes & Wilmore (1976). The results of this study in six weeks of isokinetic training, however, did not yield the magnitude of 4.92 cm demonstrated by Blattner & Noble (1979).

Although not significant, the 0.95 cm change resulting from six weeks isotonic training was comparable to the 1.01 cm increase for the isotonic group results reported by Pipes & Wilmore (1976). Neither of these results are in agreement with the plyometric results of eight weeks reported by Blattner & Noble (1979).

The results of the present study demonstrate no significant difference between the isokinetic and the isotonic training programs for both power output and vertical jump. Both experimental groups demonstrated significant improvement in maximum power output, but only the isokinetic group demonstrated a significant improvement in vertical jump. Perhaps the training duration was of insufficient length for isotonic significance to be revealed. More plausible is the thought that the increased speed of training employed by the isokinetic group, which more closely parallels the angular velocities of jumping, stimulated the neuromuscular adaptation which produced the significant improvement in the test subjects.

CHAPTER V

CONCLUSIONS

Summary

Fifty-five male subjects were randomly assigned to one of three groups, and each group was randomly assigned to a treatment. Group I trained isokinetically using the Pro Jumper, Group II trained isotonically using Olympic weights, and Group III pursued no training programs and acted as a control group. All subjects in the experimental groups trained three times per week for six weeks, with one pre-training week for orientation to equipment prior to the initial testing.

Subjects were tested for maximum power output using the Margaria-Kalamen power test and vertical jumping ability with the jump and reach test. Testing was performed initially, at four weeks and after six weeks of training for all groups.

Significant differences occurred in maximum power output for the experimental groups between initial and six week tests and between the four week and the six week tests. Vertical jumping testing revealed a significant difference as a result of six weeks of isokinetic training and a significant difference between four and six weeks of isokinetic training.

Conclusions

The following conclusions were made as a result of this study for maximum power output:

1. To accept hypothesis #1 - There would be no significant difference in maximum power output as a result of four weeks isokinetic training.

2. To reject hypothesis #2 - There would be no significant difference in maximum power output as a result of six weeks isokinetic training.

3. To reject hypothesis #3 - There would be no significant difference in maximum power output between four and six weeks of isokinetic training.

4. To accept hypothesis #4 - There would be no significant difference in maximum power output as a result of four weeks isotonic training.

5. To reject hypothesis #5 - There would be no significant difference in maximum power output as a result of six weeks isotonic training.

6. To reject hypothesis #6 - There would be no significant difference in maximum power output between four and six weeks of isotonic training.

7. To accept hypothesis #7 - There would be no significant difference in maximum power output between isokinetic and isotonic groups with four weeks training.

8. To accept hypothesis #8 - There would be no significant difference in maximum power output between isokinetic and isotonic groups with six weeks training.

The following conclusions were made as a result of this study for vertical jumping performance:

9. To accept hypothesis #9 - There would be no significant difference in vertical jumping performance as a result of four weeks isokinetic training.

10. To reject hypothesis #10 - There would be no significant difference in vertical jumping performance as a result of six weeks isokinetic training.

11. To reject hypothesis #11 - There would be no significant difference in vertical jumping performance between four and six weeks of isokinetic training.

12. To accept hypothesis #12 - There would be no significant difference in vertical jumping performance as a result of four weeks isotonic training.

13. To accept hypothesis #13 - There would be no significant difference in vertical jumping performance as a result of six weeks isotonic training.

14. To accept hypothesis #14 - There would be no significant difference in vertical jumping performance between four and six weeks of isotonic training.

15. To accept hypothesis #15 - There would be no significant difference in vertical jumping performance between isokinetic and isotonic groups with four weeks training.

16. To accept hypothesis #16 - There would be no significant difference in vertical jumping performance between isokinetic and isotonic groups with six weeks training.

Recommendations

The following recommendations are made for future study:

1. A longer training period be used with repeated testing each two weeks to determine when the effects of training occur.

2. The addition of a slow speed isokinetic group, closer in speed to that encountered in isotonic squats.

3. The inclusion of a method of strength measurement to the testing battery.

4. The inclusion of isokinetic testing to the testing battery.

REFERENCES CITED

References Cited

Ball, J. R., Rich, G. Q., & Wallis, E. L. Effects of isometric training on vertical jumping ability. Research Quarterly, 1964, 35, 231.

Bangerter, B. L. Contributive components in the vertical jump. Research Quarterly, 1968, 39, 432-436.

Berger, R. A. Effect of weight training programs on strength. Research Quarterly, 1962, 33, 168-81.

Berger, R. A. Comparison between static jumping and various dynamic training programs. Research Quarterly, 1963, 34, 131-135.

Berger, R. A. Effects on dynamic and static training on vertical jumping ability. Research Quarterly, 1963, 34, 419.

Berger, R. A. Comparison of the effect of various weight training loads on strength. Research Quarterly, 1965, 36, 141-146.

Bhanot, J. L., & Sidhu, L. S. Maximal anaerobic power in national level indian players. British Journal of Sports Medicine, 1981, 15 (4), 265.

Blattner, S. E., & Noble, L. Relative effects of isokinetic and plyometric training on various jumping performance. Research Quarterly, 1979, 50, 583-588.

Burke, E. J. Toward an understanding of human performance. Ithaca, New York: Mouvement Publications, 1978.

Campbell, C. J., Bonen, A., Kirby, R. L. & Belcastro, A. N. Muscle fiber composition and performance capacities of women. Medicine and Science in Sports, 1979, 11 (3), 260-265.

Counsilman, James E. The importance of speed in exercise. Scholastic Coach, 1976, 46, 94-99.

Coyle, E. F., Feiring, D. C., Rotkis, T. C., Cote III, R. W., Roby, F. B., Lee, W., & Wilmore, J. H. Specificity of power improvements through slow and fast isokinetic training. Journal of Applied Physiology, 1981, 51 (6), 1437.

DeLorme, T. L. Restoration of muscle power by heavy resistance exercises. The Journal of Bone and Joint Surgery, 1945, 27, 645-667.

DeVries, H. A. Physiology of exercise for physical education and athletics. Dubuque, Iowa: Wm. C. Brown Co., 1980.

Eckert, H. M. Angular velocity and range of motion in the vertical and standing broad jumps. Research Quarterly, 1968, 39 (4), 937.

Eisenman, P. A. The influence of initial strength levels on responses to vertical jump training. Journal of Sports Medicine and Physical Fitness, 1978, 18 (3), 277-282.

Fox, E. L. & Mathews, D. K. The Physiological Basis of Physical Education and Athletics. Third Edition, 1982, Saunders College Publishing.

Gardner, G. W. Specificity of strength changes of the exercised and nonexercised limb following isometric training. Research Quarterly, 1963, 34, 98-101.

Genvario, S. E., & Dolgener, F. A. The relationship of isokinetic torque at two speeds to the vertical jump. Research Quarterly, 1980, 51 (4), 593-598.

Gray, R. K., Start, K. B., & Glencross, D. J. A test of leg power. Research Quarterly, 1962, 33, 44-50

Gray, R. K. A useful modification of the vertical power jump. Research Quarterly, 1962, 33, 230-235.

Harris, R. Trampoline for all. Scholastic Coach, 1959, 28, 28.

Hickson, R. C. Interference of strength development by simultaneously training for strength and endurance. European Journal of Applied Physiology, 1980, 45 (2-3), 255-263.

Hinson, M., & Rosentswieg, J. Comparative electromyographic values of isometric, isotonic, and isokinetic contractions. Research Quarterly, 1973, 44, 71-78.

Hislop, H. G., & Perrine, J. J. The isokinetic concept of exercise. Physical Therapy, 1967, 47, 114-117.

Johnson, B. L., & Nelson, J. K. Practical Measurements for Evaluation in Physical Education. Minneapolis, Minnesota: Burgess Publishing Company, 1974.

Kansal, D. K., Verma, S. K., & Sidhu, L. S. Improvisation of a simple device in measuring the anaerobic power of indian male and female athletes. British Journal of Sports Medicine, 1981, 15, 136.

Kearney, J. T. Resistance training & development of muscular strength and endurance. In Burke, E. J. (Ed.) Toward an Understanding of Human Performance, Ithaca, New York: Mouvement Publications, 1978.

Knapik, J. J., Ramos, M. V., & Wright, J. E. Non specific effects of isometric and isokinetic strength training at a particular joint angle. Medicine and Science in Sports and Exercise, 1980, 12 (2), 120 (ABSTRACT).

Lesmes, G. R., Costill, D. L., Coyle, E. F., & Fink, W. J. Muscle strength and power changes during maximal isokinetic training. Medicine and Science in Sports and Exercise, 1978, 10 (4), 266.

Mathews, D. K. & Fox, E. L. The physiological basis of physical education and athletics. 2nd ed, Philadelphia: W. B. Saunders Company, 1976.

McArdle, W. D., Katch, F. I., & Katch, V. L. Exercise Physiology: Energy, Nutrition, and Human Performance. Philadelphia: Lea & Febiger, 1981.

McGovern, R. E., & Luscombe, H. B. Useful modifications of progressive resistance exercise technique. Archives of Physical Medicine, 1953, 34, 475-477.

Moffroid, M. T. & Kusiak, E. T. The power struggle: definition and evaluation of power of muscular performance. Physical Therapy, 1975, 55 (10), 1098.

Nagle, F. J., & Irwin, L. W. Effects of two systems of weight training on circulorespiratory endurance and related physiological factors. Research Quarterly, 1960, 31, 607-615.

Pipes, T. V., & Wilmore, J. H. Isokinetic vs. isotonic strength training in adult men. Medicine and Science in Sports, 1975, 7 (4), 262-274.

Pipes, T. V. Strength training modes: what's the difference: Scholastic Coach, 1977, 96, 120-124.

Sargeant, A. J., Hoinville, H., & Young, A. Maximum leg force and power output during short-term dynamic exercise. Journal of Applied Physiology, 1981, 51, 1175.

Scoles, G. Depth jumping! does it really work? Athletic Journal, 1978, 58, 48-75.

Talag, T. S. Residual muscular soreness as influenced by concentric, eccentric, and static contractions. Research Quarterly, 1973, 44, 458-469.

Thistle, H. G., & Hislop, H. J., Moffroid, M. A., & Lowman, E. W. Isokinetic contraction: a new concept of resistive exercise. Archives of Physical Medicine and Rehabilitation, 1967, 48, 279-282.

Thorstensson, A., Sjodin, B., & Karlsson, J. Enzyme activities and muscle strength after sprint training in man. Acte Physiol Scand., 1975, 94, 313-318.

VanDalen, D. New studies in the sargent jump. Research Quarterly, 1940, 11 (2), 112.

VanOteghen, S. L. Two speeds of isokinetic exercise as related to the vertical jump performance of women. Research Quarterly, 1975, 46, 78-84.

Wilmore, J. H. The application of science to sport: physiological profiles of male and female athletes. Canadian Journal of Applied Sport Sciences, 1979, 4 (2), 103-115.

Wilt, F. E. Plyometrics! what it is - how it works. Athletic Journal, 1975, 55, 76; 89-90.

APPENDIX A

LEG TRAINING PROGRAM

WORKOUT RECORDING FORM

WARMUP:
1) Trunk rotation - 5 each direction
2) Standing - legs straight bend to floor
3) Sitting - straddle stretch, 2 times (side, center, side) hold 5 sec. each
4) Standing - Quad stretch
5) Standing - Gastroc stretch, against wall

	SQUATS			PRO JUMPER		
	SETS	WEIGHT	REPS	SETS	SPEED SETTING	MAX SPEED
FEB 1 (M)	3				6	
3	3				6	
5	3				6	
8 (M)	3				6	
10	3				6	
12	3				6	
15 (M)	3				6	
17	3				6	
19	3				6	
22 (M)	3				6	
24	3				6	
26	3				6	
MAR 1 (M)	3				6	
3	3				6	
5	3				6	
8 (M)	3				6	
10	3				6	
12	3				6	

APPENDIX B

INFORMED CONSENT

I willingly volunteer to participate in this research study to determine the gains in vertical jumping ability and power incurred as a result of a six week leg training program using either the Pro Jumper or olympic weights. I also understand that I will be performing vigorous training exercises, and am in good enough physical condition to do so.

In any training situation, certain risks are involved. I have been fully advised of the nature of the procedure and the possible risks and complications (i.e. muscle soreness and muscle strains) involved with the testing and training programs, all of which I hereby assume voluntarily. In addition, proper weight lifting techniques and machinery usage have been conveyed to me in order to minimize possible dangers in this study.

I also understand that I may withdraw from the study at any time.

I hereby acknowledge that no representations, warranties, guarantees, or assurance of any kind pertaining to the procedure have been made to me by the University of Wisconsin - LaCrosse, the officers, administration, employees, or by anyone acting on behalf of any of them.

Signed: _____ Witnessed by: _____

Subject's Name _____ Date: _____

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