RELATIVE EFFECTS OF ISOKINETIC AND PLYOMETRIC TRAINING ON THE VERTICAL JUMP ABILITY OF COLLEGE MALES

by

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Dedication

To Carla.

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Chapter 1

INTRODUCTION AND STATEMENT OF PROBLEM

Vertical jumping ability is of considerable importance in numerous athletic events. Previous training techniques designed to improve this component have relied on increasing strength of the lower extremity. However, many athletes possess fantastic leg strength, yet they cannot jump high. They are unable to produce the power necessary in explosive-type movements. Research (2,4,5,10,18,28) has verified no significant relationship exists between leg strength and leg power. Gray (10) explained this low correlation as indicating a high specificity and low generality exists between these two variables, while Smith (28) concluded the strength component involves a different neuromotor pattern than power. Consequently, coaches and trainers are greatly interested in developing training techniques designed to improve power performance of the legs, and vertical jumping ability, and are less concerned with developing strength per se.

Three basic methods of strength and power development programs have been used: isometric, isotonic, and isokinetic. All methods have been effective in improving strength of the lower extremity (6,14,17,23,30,31). Most recently, researchers (6,7,14,15,16,25,26,29,30) have determined advantages of isokinetic training over isotonic and isometric exercise. The greatest advantage of isokinetic exercise is it allows the muscles to work at maximal force throughout an entire range of motion for each and every repetition (15,25,26,30). Additional advantages of applying the isokinetic principle include: (1) increased muscle activity during exercise, as indicated by EMG studies by Rosentswieg (25,26), (2) reduced muscle soreness (7,29,30), (3) elimination of joint discomfort (6,29,30), and (4) less susceptability to ligament or tendon damage during exercise (6,30).

While extensive research has been devoted to isokinetic exercise and its effect upon performance, there is limited evidence in American literature pertaining to a relatively new concept of strength and power training: plyometrics.

Plyometric exercise seeks to bridge the gap between sheer strength and power. Wilt (37) defines plyometrics as:

> ...the exercises of training drills used in producing an overload of isometric-type muscle action which induces the stretch reflex in muscles.

Hence the key to plyometrics is invoking the stretch reflex of muscle action. The past theory of muscle action, now regarded as a fallacy, stated muscles produce the greatest amount of force if relaxed prior to contraction. However, modern research (1,3,11,33) has verified the concept that muscles will contract far more forcefully if they are pre-stretched. Plyometric exercise seeks to train the area of muscle activity prior to the concentric contraction and immediately following the eccentric contraction, when the muscle is placed in a forced-stretch, or pre-stretch condition.

Research has shown comparisons of the effects of isotonic and plyometric training (23), but no evidence exists which compares the training effects of isokinetic and plyometric exercise on vertical jumping ability.

STATEMENT OF PROBLEM

The purpose of this investigation was to compare the effects of isokinetic and plyometric training on the vertical jump performance of college males.

LIMITATIONS OF THE STUDY

The limitations of the study are as follows:

1. Subjects may not have exerted maximal efforts during each training session.

2. Subjects may not have followed procedural guidelines concerning the execution of exercises and jump technique.

3. Subjects may not have given optimal efforts on the test for vertical jump.

DEFINITIONS OF TERMS

Several terms are specifically defined here to prevent the possibility of ambiguous interpretation.

Isokinetic training. Training with muscular contractions at a constant speed against a resistance which is a function of the force supplied.

Plyometric training. Training of the muscle action prior to the concentric contraction and immediately following the eccentric contraction, when the muscle is placed in a forced-stretch, or pre-stretch, condition.

<u>Depth jumping</u>. Jumping down from heights of between 30 and 45 inches and then immediately jumping upwards as high as possible.

DELIMITATIONS OF STUDY

The delimitations of the study are as follows:

1. The subjects were 48 volunteer college males attending Kansas State University, Manhattan, Kansas.

2. One type of test, the vertical jump-and-reach test, was administered in this study.

3. Only one specific depth jumping program and one isokinetic training program were used in the study.

Chapter 2

REVIEW OF LITERATURE

The review of literature chapter is divided into three sections. The first section presents studies relative to testing procedures, specifically preliminary exercise and jump testing. The second section reviews studies related to isokinetic exercise, specifically EMG studies, isokinetic training studies, and studies related to isokinetic speed of exercise. The final section presents material related to plyometric training, including the nature of and basis for plyometrics, and depth jump studies.

STUDIES RELATED TO TESTING PROCEDURES

This section is divided into two parts. Section one presents literature which pertains to preliminary exercise, and part two discusses jump testing research.

Preliminary Exercise

Pacheco (22) conducted two experiments to determine the effects of preliminary exercise on jump performance. The initial study involved ten subjects, nine male and one female. Each subject executed 90 jumps preceded by either isometric stretching exercises, running in place, or knee bends. Results showed vertical jump performance significantly improved when preceded by any of the warm-up exercises. The follow-up study involved 50 college males who were randomly divided into a control group and an exercise group. Each subject performed ten vertical jumps. Results showed the group using the warm-up exercises improved from 2.9

to 7.8 per cent in vertical jump performance.

Richards (24) found improvement in jump performance in sixteen-year-old females following a one to two minute warm-up exercise. Eighty subjects were divided into four groups and tested at one, two, four, and six minute work tasks prior to jump testing. Results showed one and two minute warm-up periods improved performance approximately twenty per cent, while at the four minute level no effect was present, and at the six minute workload a deficit of twenty-seven per cent occurred.

Measuring Vertical Jump

The Sargent jump test was developed in 1921 to measure the capacity of man to overcome gravity. McCloy (19) later interpreted the Sargent test as a test of the body to develop power relative to the weight of the individual. Because the Sargent jump test allows the subject to use his arms, many researchers have felt this was not a true test of leg power.

Gray and others (10) conducted a study to determine a more efficient method of testing leg power. Four tests were investigated: the modified vertical power jump, the jump-and-reach test, the standing broad jump, and the squat jump. These tests were compared with the standard power jump Gray had devised earlier (9). Results showed the modified vertical power jump had a validity coefficient of .989. The squat jump yielded a value of .840, while the standing broad jump measured .682, and the jump-and-reach test showed a value of .954. This establishes both the jump-and-reach and modified vertical power jump tests as reliable and valid measures of leg power and vertical jump ability.

Although researchers do agree that an average of trials is more reliable than a best score when gathering data from a jump test (4,12,20,36), there seems to be no general agreement with regard to the number of trials used in scoring the vertical jump-and-reach test. Henry (12) found a reliability coefficient of .88 when taking the average of three trials. McCraw (20) concurred with Henry, recommending the average of three scores would be the best method. Herman (13) found a reliability of .986 using trials two, three, and four and determining an average from the three. Considine (4) obtained a reliability figure of .989 using an average of trials three, four, five, and six on the vertical jump-and-reach test. Parcell (23) computed a reliability figure of .992 while averaging the scores from trials two through five. Because these coefficients were gathered from various subjects and conditions, the only conclusion that can be drawn when determining the optimal method of scoring the data for the jump-and-reach test is that all methods yield acceptable reliability.

STUDIES RELATED TO ISOKINETIC EXERCISE

This section is divided into three parts. Part one reviews isokinetic EMG studies, part two presents isokinetic strength and power training studies, and part three discusses literature relevant to isokinetic speed of exercise training studies.

EMG Studies

Rosentswieg and Hinson (26) employed EMG techniques to examine differences between isometric, isotonic, and isokinetic contractions in terms of electrical activity elicited by each. Thirteen women each performed one maximal isotonic and isokinetic contraction of the dominant arm, and one maximal isometric contraction at four different angles of the dominant arm. Muscle activity of the biceps brachii was monitored through the use of an integrator, coupled with an electronic counter, which continuously displayed microvoltages throughout the contractions. Results determined isokinetic work was the preferred exercise for strength development of the biceps brachii.

Hinson and Rosentswieg (15) also compared the effects of isometric, isotonic, and isokinetic exercise on 52 college women. The electrical activity present in the biceps brachii during contraction was used as the indicator of strength. Each subject performed one maximal isotonic and isokinetic contraction of the dominant arm, and one maximal isometric contraction at four different angles of elbow flexion of the dominant arm. Results indicated isokinetic exercise caused significantly more electrical activity in the muscle, as well as the greatest amount of strength gain.

Rosentswieg and others (25) used EMG techniques to study selected forearm and shoulder muscle activity during an isokinetic bench press performed at three speeds. Eleven college women served as subjects for the experiment, and each subject performed three trials at each separate speed. Speeds represented slow, moderate, and fast contraction periods, and were set so completion of a bench press repetition would require 3.5, 2.0, and 1.5 seconds. The muscle action potentials of the anterior deltoid, pectoralis major, biceps brachii, and triceps muscle were studied by a quantitative EMG. Bipolar surface electrodes with standard placement were employed throughout the study. EMG data was obtained through integrated bioelectric moniters, which integrated the muscle action potentials and sent to an electrical digital counter the data in average, absolute voltage elicited by the muscle contraction. Results indicated the slowest speed setting (3.5 seconds) elicited a much greater electrical output than the two faster speeds. Rosentswieg also concluded the amount of work performed over a longer period of time is related to slower speed work elicited more rapid strength gains than at fast speed contractions.

Isokinetic Training Studies

Knight and George (17) randomly divided 39 college males into isotonic, isokinetic, and control groups to compare effectiveness of the training methods. Subjects in the experimental groups trained three times a week for six weeks. The isokinetic group performed three sets of six repetitions per set of an isokinetic squat exercise per training session. The isotonic group performed three sets of six repetitions per set of a squat exercise using barbells as the resistive load. Resistance was set at 70 per cent maximum the first two weeks, 80 per cent maximum the third and fourth weeks, and 90 per cent maximum the final two weeks. All three groups were pre-tested and post-tested for maximum power by Margaria's Power Staircase Test. Results showed no significant difference between experimental groups, although both groups did show significant strength gain.

Thistle and others (32) compared the effects of isokinetic, progressive resistance, and isometric training on 51 subjects. Subjects were randomly divided into three training groups and one control group. Subjects in the three experimental groups trained four days a week for eight weeks. On the fifth day of each week, subjects from all training and control groups were tested on an isokinetic apparatus and torque curves were recorded. From these readings, total work and peak force ability were calculated. Results showed the isokinetic training group had a greater increase in both total work and peak force ability than did the remaining exercise groups.

Testone (31) conducted a study to determine the effects of isokinetic training on vertical jump ability. Forty subjects were randomly divided into a control group and training group. The training group exercised four times a week for six weeks, performing 15 leg extensions per training session. Results showed strength and vertical jump ability of the training group significantly improved.

Escutia (8) compared repetitive jumping and isokinetic training and their effects on vertical jump ability on 53 male subjects. Subjects were randomly divided into two training groups and one control group. The training groups exercised two times a week for seven weeks, with the isokinetic group performing ten squat extensions per session, and the repetitive jump group executing 25 repetitive jumps against no resistance per training session. Results showed strength and vertical jump performance did not significantly improve using either training method.

Tanner (30) trained 27 college males isokinetically and isotonically to compare training effects on vertical jump ability. Subjects were randomly assigned to a control group, isotonic training group, and an isokinetic training group. Both training groups performed the half squat and heel raise exercises three times a week for six weeks. The isotonic group performed three sets of each exercise per training session. The initial two sets required eight repetitions, while the final set required a maximal number of repetitions. The first day of training each subject used a resistance of one-half his body weight, and succeeding training day's weights were determined by the number of repetitions of the third set the preceding day. Five pounds was either added or subtracted for every three repetitions over or under eight. The isokinetic group performed three sets of eight repetitions per set of each exercise per training session. Results indicated both training groups improved significantly in vertical jump ability; however, no significant difference in vertical jump performance occurred between training groups.

Speed of Exercise Studies

Hunter (16) compared two speeds of isokinetic training on the vertical jump ability of 16 college male basketball players. Subjects were randomly assigned to one of three groups: Group I trained four times a week for eight weeks, employing a fast speed-high repetition technique for three days, and a slow speed-low repetition method the final training session; Group II trained four days a week for eight weeks, using the slow speed-low repetition method for three days, and the fast speed-high repetition method the final training session; Group III served as a control group. Fast speed workouts required 35 repetitions, while slow speed exercises required ten repetitions. Subjects in the training groups performed the seated military press and parallel squat exercises during each training session. Results determined the fast speed-high repetition method of training was more effective in producing gains in vertical jump ability, although both methods did show improvement.

Van Oteghan (34) compared two speeds of isokinetic exercise as a means to increase vertical jump ability of college women. Forty-eight intercollegiate volleyball players were randomly divided into three groups: control, slow speed, and fast speed. Each of the experimental groups trained three days a week for eight weeks, performing three sets of ten leg press repetitions. Speeds of the exercises were controlled at four seconds per repetition at the slow speed, and two seconds per repetition at the fast speed. Results showed both training groups were superior to the control group on vertical jump performance; however, one isokinetic speed was no more effective than the other in significantly improving vertical jump performance.

Moffroid and Whipple (21) trained 28 subjects isokinetically to evaluate the effects of two different training speeds on muscular endurance and muscular force. Subjects were randomly assigned to one of three groups: an exercise group to work at slow velocities only (Group I), an exercise group to work at high velocities only (Group II), and a control group (Group III). Each training group exercised three times a week for six weeks. Training sessions consisted of two minutes of alternate extension and flexion at the knee joint without rest. Subjects in the slow speed exercise group performed six revolutions per minute, while the fast speed group exercised at 18 revolutions per minute. Results showed the low speed exercise group produced greater increases in muscular force only at slow speeds, while the high speed training group produced increases in muscular force at speeds of contraction at and below the training speed.

STUDIES RELATED TO PLYOMETRIC EXERCISE

This section is divided into two parts: the initial portion presents literature related to the nature of and basis for plyometrics, while the final section discusses depth jump studies.

The Nature of and Basis for Plyometrics

Wilt proposed that plyometric exercise, i.e., depth jumping, be included in training procedures to train the pre-stretch condition of muscle action--an aspect ignored in isometric, isotonic, and isokinetic techniques. The theory underlying depth jumping is based on the principle that the kinetic energy of the falling body is used for stimulation of muscle action, rather than overloading by conventional means (27).

Bannister (1) theorized a muscle will be able to lift a greater load the greater it is pre-stretched from its natural length prior to contraction.

Grieve (11) stated the faster a muscle is allowed to shorten, the less tension it can exert. Conversely, the faster a muscle is forced to lengthen, the greater the tension it exerts. Hence, the rate of stretch outweighs the degree of stretch.

Cavagna and others (3) found the positive work done by a muscle which shortens immediately after being stretched was found to be greater than the positive work done by the same muscle during shortening from a state of isometric contraction. These results were determined from experiments done on the isolated toad sartorius and frog gastronemius, and on the male forearm flexors. This study also concluded that potential energy stored in a previously stretched muscle is partially responsible for a more powerful contraction, as the greater work obtained when the muscle was allowed to shorten immediately after being stretched was due to elastic energy release during the stretching phase. An increase of stretching speed of the muscle would allow for the capacity of elastic energy release to be greater.

Thys and others (33) discovered results similar to Cavagna, as he concluded the elastic energy stored in a stretched muscle during an eccentric contraction was utilized for the performance of positive work. Six subjects performed an exercise of bending deeply at the knees, followed by extension of the legs to return to the upright position at a rate of 20 repetitions per minute. One of the groups tested (no rebound) performed the exercise with a pause of 1.5 seconds between knee flexion and extension, while the other group (rebound) performed the exercise with knee flexion immediately following knee extension. Additional results from the experiment included the rebound group experienced a higher maximum speed during the extension phase of the exercise, while taking less time to perform.

Depth Jumping Studies

Research related to depth jump exercise is limited in American literature. Verhoshanskiy (35) used the height of two feet, five and one-half inches for development of maximal speed, and three feet, seven and one-quarter inches for development of maximal dynamic strength in depth jump training of Russian athletes. He further stated a non-trained athlete should perform depth jumps no more than one session per week, with a maximum of 30 repetitions per training session.

Wilt (37) stated heights for depth jump training of jumpers should be between 30 and 45 inches, with no more than two training sessions per week, and a maximum of 40 jumps per session.

Herman (13) trained 32 subjects plyometrically twice a week for five weeks to determine the effect of depth jumps on vertical jump ability of college males. Heights for the depth jumps were determined from Verhoshanskiy's theory. Group I trained at the low height (2'5½"), Group II trained at the high height (3'7¼"), and Group III trained at both heights. Group IV served as a control group. Subjects performed 12 depth jumps per session the first week, and increased the number of jumps by two each following week. Results from the experiment showed depth jumping did not improve vertical jump ability of college males.

Scoles (27) conducted a study to determine the effects of depth jumping on the vertical jump and standing long jump of college males. Twenty-six physical education majors were randomly divided into three groups: Group I served as the plyometric training group, Group II served as a flexibility training group, and, Group III served as a control group. Group I trained twice a week for eight weeks, performing 20 depth jumps per session from a height of .75 meters. Group II exercised twice a week for eight weeks, performing stretching exercises of the hamstrings, quadriceps, and lower back muscle groups. Results from the experiment showed that although no significant difference existed between training groups, the plyometric group showed greater improvements in both vertical jump and long jump performance.

Parcell (23) compared the effects of isotonics and plyometrics on the vertical jump ability of college males. Forty-five subjects were randomly assigned to three groups: Group I was the isotonic training group, Group II was the plyometric training group, and, Group III served as the control group. Both experimental groups trained twice a week for six weeks. The isotonic training group performed a half squat into a heel raise with a 50-pound barbell placed on the subject's shoulders. This exercise was performed eight times the first week, and two additional repetitions were included each following week. The plyometric training group performed ten repetitions of depth jumps the first week, with an addition of one repetition to each set each following week. The height of the depth jump varied from 2'5½" the first three weeks, and 3'7¼" the final three weeks. Results showed the plyometric method of training was more effective in producing gains in vertical jump ability.

SUMMARY

A thorough review of the literature supports the following:

1. Preliminary exercise has been proven to increase vertical jump capacity from 2.9 per cent, to approximately 20 per cent. The duration of this warm-up period has been recommended to be from one to two minutes.

2. Validity coefficients have indicated the modified power vertical jump (.989) and the jump-and-reach (.954) tests are both acceptable methods of measuring vertical jump ability. However, although researchers do agree an average of trials is the most reliable method of obtaining a criterion measure, no general agreement exists regarding the number of trials to use.

3. EMG studies have indicated isokinetic exercise is the preferred method of developing strength, determined by the amount of electrical activity elicited during a muscular contraction. Isokinetic exercise may not always improve jump capacity, but research has generally agreed that the isokinetic method of training will develop strength and power.

4. Training isokinetically at different speeds has been used to determine the effects on strength and power performance. Results have indicated that both fast and slow speeds of exercise will increase muscular force. The fast speed of exercise has also proved to provide a greater increase in jump ability in one instance, although in another study neither speed produced greater gains in jump performance.

5. Plyometric exercise seeks to train the pre-stretch condition of muscle action--an aspect ignored in isometric, isotonic, and isokinetic training techniques. Research has concluded a muscle will contract far more forcefully if the concentric contraction is immediately preceded by an eccentric contraction.

6. Research has recommended depth jumps be performed from heights of 30 to 45 inches, with no more than two training sessions per week, with a maximum of 40 jumps per session.

7. Depth jumping has not always significantly increased vertical jump capacity. but limited studies do agree that this method will induce vertical jump gain.

Chapter 3

PROCEDURES

This chapter gives a detailed account of the procedures involved in this study. The study was conducted March 20--May 12, 1978. The model 16 BX "Leaper" machine was used with the consent of the Kansas State University Mens Basketball Coaching staff, and boxes used for the depth jumping exercises were donated from the Kansas State University Mens Track Coaching staff.

SELECTION OF SUBJECTS

Forty-eight subjects were selected from male volunteers enrolled at Kansas State University in the spring semester of 1978. Each subject was randomly assigned to a training group: Group I trained isokinetically, Group II trained plyometrically, and, Group III served as a control group. None of the subjects were involved in either an intercollegiate sport or other training program during the experiment. In order to ensure consistency in performance during the training program, all subjects were instructed on vertical jump technique and procedural guidelines for isokinetic and plyometric exercise performance. Subjets who were either injured during the training period or failed to train the recommended number of sessions per week were dropped from the study.

TESTING PROCEDURES

Criterion jump measures were recorded using the jump-and-reach test for all training and control groups prior to and at the conclusion of the training period. Subjects were administered six trials of jump ability, and a mean score of trials three, four, five, and six were used as criterion measures. A vertical jump board, marked in inches, was hung from ceiling rafters for ease in taking jump measurements. A maximum of 30 seconds was allowed between each jump trial. All jump test scores were recorded by the principle investigator.

When tested for jump ability, all subjects followed the following standard guidelines:

1. The subject stood behind a line three inches behind the suspended vertical jump board.

2. The subject's feet were placed approximately shoulder-width apart.

3. The subject chalked the fingers of his preferred hand.

4. No preliminary foot movements were allowed, but the subject's arm movement and knee flexion were self-determined.

5. The subject jumped as high as possible, touching the suspended measurement board at his maximum height with the preferred hand.

TRAINING REGIMEN

Subjects in the plyometric and isokinetic groups trained three times a week for eight weeks, and each training session consisted of warm-up exercises followed by respective training procedures.

The warm-up exercises were performed as follows:

1. Ten passive leg stretches with each leg, performed as follows: the subjects sat on the floor with the preferred leg extended directly

forward, with the foot of the non-preferred leg placed adjacent to the hip. The subject then brought his nose to the knee, keeping the extended leg straight, and holding this position for a count of seven.

2. Ten passive shoulder stretches, performed as follows: the subject stood approximately three feet from a wall and placed both hands as high on the wall as possible. The subject then pushed his chin toward the floor, and held this position for a count of seven.

3. Ten sit-ups.

4. Ten push-ups.

5. Run in place for 60 seconds.

The isokinetic training group exercised three times a week for eight weeks. Each workout consisted of the warm-up exercises, followed by three sets of ten repetitions per set performed on the Model 16 BX "Leaper" leg press machine, an isokinetic exerciser manufactured by Mini-Gym Incorporated of Independence, Missouri. The pulley mechanism of the "Leaper" prevented both the occurrence of a ballistic movement as the legs forcefully extended, and the eccentric muscle contraction between repetitions, while keeping muscular resistance always balanced precisely and proportionately to the user's input. An accomodator dial mechanism recorded the units of pressure exerted, measurable to 1800 pounds.

For each repetition performed on the "Leaper" the subject executed the action as rapidly and with as much effort as possible. Completion of a repetition occurred when the legs extended until no further pressure could be applied with the balls of the feet, followed by retraction and return to the original starting position. The rate of the pulley mechanism was set at the fast speed, or 1.47 feet per second. A rest period of two minutes was allowed between performance of sets.

The plyometric training group exercised three times a week for eight weeks. Plyometric workouts consisted of the warm-up exercises, followed by three sets of ten repetitions per set of depth jumps. Depth jumps were performed from the following starting position: the subject stood on a box 34 inches above the floor with the feet approximately shoulder-width apart. The exercise itself consisted of jumping to the floor and immediately jumping upward with maximal effort. A one-inch gymnastics floor mat, manufactured by Nissen Company of Cedar Rapids, Iowa, was placed on the floor to aid in cushioning the fall. During the first two weeks of the training period, subjects performed the exercises with no resistance. Then, at the beginning of week three, progressive resistance was applied. At this time, a ten-pound weighted vest, manufactured by Elmer's Weight Company, of Fort Worth, Texas, was worn during the jump exercises. At the beginning of weeks five and seven, five additional pounds were added to the previous week's resistance, so that by week seven, the resistance totaled 20 pounds. A rest period of two minutes was allowed between performance of sets.

Subjects were given verbal encouragement from both their peers and the principle investigator. During performance of the exercises, at least another fellow subject or the principle investigator were present in the training rooms.

STATISTICAL PROCEDURES

Covariance analysis was used to compare post-test scores with the effect of pre-test differences removed. Least Significant Differences were computed to determine the significance of group differences.

Chapter 4

RESULTS AND DISCUSSION

This chapter is divided into three sections. The material in the first section presents descriptive statistics for pre-test and post-test data, as well as an interpretation of the covariance analysis for post-test scores. The second section presents a comparison of group means as revealed by Least Significant Differences scores. The final section presents a discussion of these results. Raw scores for all subjects may be found in the Appendix.

COVARIANCE ANALYSIS OF POST-TEST SCORES

Table I gives the pre-test and post-test means, variance, kurtosis, and skewness data for all groups. The only marked deviation from normality in any of the groups occurred in the skewness index in the control group. This may be in part due to one extremely low score in the group. The lack of homogenity of variance, which is a basic assumption of the covariance analysis study, occurred in that the variance in the control group is approximately six times greater than that of the plyometric group. This deviation may have affected the precision of the F-test. Note the control group scored substantially lower than the treatment groups on both the pre-test and post-test. This may be partially explained by one extremely low score in the control group. (Appendix, Subject 309). Also, the plyometric group had a slightly higher pre-test mean score than did the isokinetic group, and showed a larger gain from pre-test to post-test.

The correlation between pre-test and post-test scores was .9171. This indicates that 85 per cent of the variability in post-test scores can be attributed to differences in post-test scores.

TABLE I

DESCRIPTIVE STATISTICS

Groups	Mean *	Variance	Kurtosis	Skewness
Pre-test				
Isokinetic	22.542	4.578	-0.108	-0.024
Plyometric	22.977	1.743	0.813	0.047
Control	20.750	10.241	1.300	-0.822
Post-test				
Isokinetic	24.479	4.278	0.030	0.644
Plyometric	25.023	1.743	0.409	-0.734
Control	21.033	8.508	4.645	-1.379

* Scores are in inches.

Table II gives the results of covariance analysis on post-test scores. The analysis is three-fold: (1) a test to determine if $\overline{B}$, the slope of the pooled regression line between pre-test and post-test scores, is zero; (2) a test to determine if the within-group regression slopes are equal; and, (3) a test to determine if the post-test axis intercepts of the within-group regression lines are equal. The first two tests are tests of basic assumptions of covariance analysis and the latter test is to determine if the treatment effects are different. Beta scores (the slopes of within-group regression lines between pre-test and post-test scores) and alpha scores (the intercepts of within-group regression lines) were determined from the analysis data.

TABLE II

COVARIANCE ANALYSIS ON POST-TEST SCORES

Source	Df	SS	Mean Squares	F-Ratios	Probabilities
pooled slope	2	27.6214	13.8107	23.766	> 0.0001
within-slope	2	0.0805	0.0402	0.069	0.9333
intercepts	1	86.4979	86.4978	148.851	> 0.0001

Based on the assumption that the slope of the pooled regression line between pre-test and post-test scores is zero, the probability of the data yielding the computed F-ratio 23.766 due to chance alone is less than .0001. Hence, the null hypothesis that $\bar{B} = 0$ is rejected.

The probability of the within-group slopes being equal (HO: $B_1 = B_2 = B_3$) was also tested. Assuming that all three slopes are equal, the computed F-ratio (.069) would occur due to chance alone 93 per cent of the time. Hence, if this study were replicated 100 times, in 93 instances the within-slope regression lines would be equal. Therefore, the data complies with the fundamental assumption of homogenity of within-class regression underlying the covariance of analysis.

The covariance analysis data reveals the probability of observed differences among adjusted post-test means is less than .0001. In other words, based on the assumption that the intercepts of the adjusted post-test means are equal ($H_o: \mu 1 = \mu 2 = \mu 3$), the probability of an F-ratio of 148.851 occurring due to chance alone would be less than .0001. This finding supports the hypothesis that treatment effects are different.

DIFFERENCES AMONG GROUPS

To explore specific group differences, Table III gives Least Significant Differences among adjusted post-test means, determined at the .05 level.

TABLE III

LEAST SIGNIFICANT DIFFERENCES **

Groups	Differences	Standard Error	Least Sig. Dif.
I & II	-0.158538	0.310032	.633086
I & III	1.862211	0.301107	.614860 *
II & III	2.020749	0.315235	.642710 *

* Difference is statistically significant.
** All scores are in inches.

These data reveal no significant difference between Groups I and II (isokinetic and plyometric), as a figure of .633086 was needed, and an actual figure of -0.158538 was derived. However, a significant difference was found between Groups I and III (isokinetic and control), as indicated by a L.S.D. of .614860 inches needed and 1.862211 obtained, and between

Groups II and III (plyometric and control), as depicted by the figures of .642710 inches needed and 2.020749 inches obtained.

DISCUSSION

At the outset of this experiment, a total of 48 male subjects were randomly assigned to one control and two treatment groups. By the time the training period elapsed, ten subjects (one control, four isokinetic, and five plyometric), had been dropped from the study as a result of either injury or delinquent attendance. Of these ten subjects who failed to complete the training regimen, three isokinetic and three plyometric subjects were released form the study due to injury non-related to the training programs. The remaining subjects were dropped from the study due to delinquent attendance.

Analysis of pre-test scores of subjects in the training groups who dropped the study revealed a mean score of 23.45 inches, with specific pre-test group means as follows: (1) isokinetic--24.375 inches; (2) plyometric--22.85 inches; and, (3) control--22.75 inches. Comparisons of these figures with pre-test figures in Table I distinguish little difference in mean scores, except in the isokinetic, where the subjects who dropped out of the study showed mean scores two inches higher than the pre-test group mean of the subjects who completed the study. Hence, the scores of the subjects who dropped from the study were similar to those who completed the training program.

The results from this study indicate no significant difference between treatment groups. This may in fact be due to no real difference in training effects. However, this lack of a significant difference could possibly be due to other factors, including insufficient statistical power. Also, incorporating different training methodologies may possibly give different results. Time limited the number of weeks the training sessions could be conducted. A longer training period may have induced greater changes in either training group. An increase in the number of training sessions per week could have also brought about more significant increases.

Results from this investigation did not concur with those of Herman (13), who found no significant difference occurred when applying the plyometric technique. However, studies by Scoles (27) and Parcell (23) coincide with the findings of the present study, as increases in vertical jump capacity can be attributed to depth jump training. Still, none of the previous three studies incorporated the use of weighted vests as an added increase in resistance during the jump exercise. Possible additional increases via depth jumping may have occurred if subjects would have jumped from a height of more than 34 inches, similar to Parcell's methodology.

The results of the isokinetic training group also agree with recent research findings, as Group I showed an increase in jump capacity of nearly two inches. Possible additional increases may have occurred if the number of repetitions per set and sessions per week were increased, similar to Hunter's technique.

Table I also indicates the plyometric training group showed a greater increase in jump capacity. This phenomenon may be explained by the similarity in jump testing and training exercises. Both depth jumping and the jump-and-reach test allow full arm movement, while the isokinetic exercises use no arm movement while performing the leg press exercises.

Still, this discrepency did not weaken the study, as it was designed to measure vertical jump capacity, not power of the lower extremities. The differences in these training methods may have aided one group in obtaining higher scores on the criterion measure.

Those subjects who attended training sessions regularly showed more significant gains in jump capacity. Scores from post-test criterion measures indicated the greatest gains in jump capacity occurred when subjects missed no more than three training sessions. The average mean score of this group was in increase of 2.625 inches, with the raw data scores ranging from gains of 2.25 to 3.0 inches. Those subjects who missed between four and six training sessions showed an average increase of 1.9090 inches, with gains ranging from 1.25 to 2.25 inches. Finally, those subjects who missed between seven and eight exercise sessions showed gains of from .75 to 1.50 inches, with a group mean of 1.1875 gained.

Some subjects experienced some pain in the quadriceps muscle group during and after training sessions during the initial few weeks of training. This might be explained by the fact the subjects were non-athletes and not accustomed to extensive training techniques. This muscle discomfort may have affected both the physical efforts of the subjects during some training sessions, and the results of the study.

Although both training methodologies did increase vertical jump capacity, some question may be raised concerning safety of the training techniques. Training isokinetically has been proven to elicit jump gains, and joint and muscle discomfort have been reported to be almost non-existent. Training plyometrically, however, has been suspect in this area. Reports have indicated muscle strain, shin splints, and ankle and knee strain have occurred while using the plyometric technique in previous training studies. Female athletes have reported excessive discomfort in these areas when subjected to depth jump training. However, documented studies involving females using depth jumping are non-existent. Results from this study show that depth jumping from a height of 34 inches, using progressive resistance of ten, fifteen and twenty pounds, cause minimal joint and muscle discomfort in male college non-athletes. However, these results are population specific.

Chapter 5

SUMMARY AND CONCLUSIONS

This chapter is divided into three parts. Part one presents a summary of this experiment, part two reveals conclusions drawn from the study, and part three gives recommendations for future consideration.

SUMMARY

The purpose of this study was to compare the effects of isokinetic and plyometric training on the vertical jump performance of college males.

This study was conducted in the spring semester, 1978, at Kansas State University. The subjects were 48 college males, used on a voluntary basis. None of the subjects were involved in either an intercollegiate sport or other training program during the experiment.

Criterion jump measures were recorded using the jump-and-reach test for all training and control groups prior to and at the conclusion of an eight week training period. Subjects were administered six vertical jump trials, with the average of the final four trials used as the criterion measure.

Members of the training groups each trained three times a week for eight weeks. Each training session consisted of three sets of ten repetitions per set of either an isokinetic leg press, or a plyometric depth jump. The isokinetic training group exercised on a 16 BX "Leaper" machine, set at the fast speed (1.47 feet per second), while the plyometric group performed depth jumps from a height of 34 inches. Progressive resistance of ten, fifteen, and twenty pounds was added at the beginning of the third, fifth, and seventh weeks.

Covariance analysis was used to compare post-test scores with the effect of pre-test differences removed. Least Significant Differences were used to determine differences among adjusted post-test means, determined at the .05 level.

The results indicated a significant difference between each training group and the control group, although no significant difference existed between training groups.

CONCLUSIONS

Within the limits of this investigation, the following conclusions are supported:

1. Plyometric training (depth jumping) increases vertical jumping ability.

2. Isokinetic training (using the 16 BX "Leaper") increases vertical jumping ability.

3. Neither isokinetic nor plyometric training yields greater increases in vertical jumping ability.

RECOMMENDATIONS

The following recommendations might be considered for further study when comparing these training methodologies:

1. It is suggested that more resistance be used in the depth jump training program, i.e., additional weight in the vests, and that the subsequent treatment be compared with the isokinetic training.

2. It is suggested that additional repetitions per set be used for both training regimens.

3. It is recommended that the length of the training program be increased for both training groups.

In addition, it is recommended that different depth jumping programs using different repetitions per set, height, sessions per week, and resistance per repetition using weighted vests be compared to determine the best plyometric program for increasing vertical jump ability.

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APPENDIX

APPENDIX

RAW SCORES *

* All scores were recorded in inches.

(Isokinetic Group)

Subject	Attendance	Standing Reach	Trial #3 pre	Trial #3 post	Trial #4 pre	Trial #4 post	Trial #5 pre	Trial #5 post	Trial #6 pre	Trial #6 post	Mean pre	Mean post
101	20	16	39	40	40	42	38	41	40	42	23.25	25.25
102	17	10	34	36	35	36	35	37	36	37	25.00	26.50
103	21	10	35	38	36	39	37	39	36	39	26.00	28.75
104	16	20	42	43	41	42	42	43	42	42	21.75	22.50
105	21	15	37	36	35	38	35	40	36	39	20.75	23.25
106	18	7	32	33	32	34	33	34	32	33	25.25	26.50
107	20	14	36	36	36	38	36	39	36	40	22.00	24.25
108	19	11	31	34	33	34	31	33	32	35	20.75	23.00
109	21	17	40	41	40	44	40	42	40	43	23.00	25.50
110	23	2	20	22	20	23	21	24	21	25	18.50	21.50

APPENDIX (cont.)

Subject	Attendance	Standing Reach	Trial #3		Trial #4		Trial #5		Trial #6		Mean	
			pre	post	pre	post	pre	post	pre	post	pre	post
111	20	4	27	28	26	27	24	27	26	27	21.75	23.25
112	18	7	30	31	30	30	30	31	28	30	22.50	23.50
(Plyometric Group)												
201	18	8	31	32	31	34	31	33	31	33	23.00	25.00
202	16	8	29	30	30	31	31	31	30	32	22.00	23.00
203	19	9	32	35	33	34	32	33	32	34	23.25	25.00
204	18	15	38	40	38	41	39	40	39	41	23.50	25.50
205	17	10	35	37	35	36	35	38	37	37	25.50	27.00
206	23	4	27	29	26	29	27	29	27	30	22.75	25.25
207	20	7	30	33	31	32	31	34	32	33	24.00	26.00
208	21	11	32	35	34	35	32	36	34	36	22.00	24.50
209	20	14	34	36	34	37	35	36	35	37	20.50	22.50
210	23	18	39	42	40	43	41	44	41	44	22.25	25.25

APPENDIX (cont.)

Subject	Attendance	Standing Reach	Trial #3 pre	Trial #3 post	Trial #4 pre	Trial #4 post	Trial #5 pre	Trial #5 post	Trial #6 pre	Trial #6 post	Mean pre	Mean post
211	21	13	36	39	37	40	37	38	38	40	24.00	26.25
(Control Group)												
301	--	7	32	32	34	34	33	34	33	33	26.00	26.25
302	--	10	33	32	33	32	34	33	33	34	23.25	22.75
303	--	17	35	36	34	36	35	35	36	37	18.00	19.00
304	--	10	32	32	32	33	33	33	33	33	22.50	22.75
305	--	11	35	32	34	32	34	33	34	33	23.25	21.50
306	--	16	35	37	36	37	35	37	36	37	19.50	21.00
307	--	12	34	33	33	32	33	34	34	33	21.50	21.00
308	--	5	25	26	25	26	26	26	26	27	20.50	21.25
309	--	12	25	25	25	24	25	25	25	25	13.00	12.75
310	--	17	38	37	39	39	38	38	38	38	21.25	21.00
311	--	7	26	27	26	28	26	27	26	27	19.00	20.25

APPENDIX (cont.)

Subject	Attendance	Standing Reach	Trial #3 pre	Trial #3 post	Trial #4 pre	Trial #4 post	Trial #5 pre	Trial #5 post	Trial #6 pre	Trial #6 post	Mean pre	Mean post
312	--	13	35	36	35	36	36	35	35	35	22.25	22.50
313	--	6	29	30	30	29	30	29	31	30	24.00	23.50
314	--	2	22	23	23	22	22	24	22	23	20.25	21.00
315	--	11	28	30	28	29	28	31	28	30	17.00	19.00

VITA

Stuart Eugene Blattner was born December 17, 1954 in Larned, Kansas, the son of Evelyn and Eugene Blattner. He attended Pawnee Heights High School at Rozel, Kansas from 1969-1972. From 1973-1977 he attended Kansas State University, Manhattan, Kansas, and received a Bachelor of Science degree in Secondary Physical Education. On January 8, 1977, he married the former Carla Ann Berger. From June 1977 until July 1978, he attended the Graduate School at Kansas State University, majoring in Physical Education. During the school year 1977-78, he was employed as a Graduate Assistant with the Recreational Services Department, Kansas State University.

RELATIVE EFFECTS OF ISOKINETIC AND PLYOMETRIC TRAINING ON THE VERTICAL JUMP ABILITY OF COLLEGE MALES

by

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This Study sought to determine the effects of isokinetic and plyometric training on the vertical jump ability of college males. Forty-eight volunteer males were randomly assigned to one control and two training groups. None of the subjects were involved in either intercollegiate athletics or other weight training program prior to or during the experiment. Subjects in the training groups trained three times per week for eight weeks. The isokinetic group performed three sets of ten repetitions per set of leg presses per training session, while the plyometric training group performed three sets of ten repetitions per set of depth jumps from a height of 34 inches, with added resistance beginning with weeks three, five, and seven of ten, fifteen, and twenty pounds, respectively.

Prior to and at the end of the training period, all subjects were given a vertical jump-and-reach test. A criterion measure was determined from an average of the final four of six jump trials. Covariance analysis was used to compare post-test scores with the effect of pre-test differences removed. Least Significant Differences were computed to determine the significance of group differences.

Results showed both training groups significantly improved in vertical jump capacity. However, no significant difference existed between training groups.