THE EFFECTS OF ISOMETRICS, ISOTONICS, AND COMBINED ISOMETRICS-ISOTONICS ON QUADRICEP STRENGTH AND VERTICAL JUMP PERFORMANCE

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ABSTRACT

Title: The Effects of Isometrics, Isotonics, and Combined Isometrics-Isotonics on Quadricep Strength and Vertical Jumping Performance

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Abstract: The purpose of this investigation was to determine the effects of isometrics, isotonics, and combined isometrics-isotonics on quadricep strength and vertical jumping ability.

Subjects for the research were twenty-four male students enrolled in Appalachian State University during the spring quarter of 1971, taking P. E. 119 (weight training).

Cable tension tests for quadricep strength and vertical jump tests were administered to the subjects before and at the conclusion of nine weeks of training. The subjects were randomly assigned to one of three experimental groups or to a control group. Training was done isometrically, isotonically, and isometronically with the extension of the right and left knee.

The raw data were treated with an analysis of covariance program to determine any significance of difference among the post means of the four groups. *t* tests were utilized to indicate those groups that were significantly

different from the others and to indicate which groups made significant gains in quadricep strength and vertical jump performance. The statistical analysis resulted in these conclusions:

1. Isotonic exercise was significantly superior to control group activity and non-significantly different from isometric exercise in the development of static strength of the quadriceps.

2. Isotonic, isometric, and isometronic training resulted in significant increases in static strength of the quadriceps.

3. There were no significant differences among post-test means of the isotonic, isometric, and isometronic, and control groups in the development of vertical jumping performance.

4. Isotonic, isometric, and isometronic training resulted in no significant increas in vertical jumping performance.

As a result of this investigation into the effects of isometric, isotonic, and combined isometrics-isotonics on quadricep strength and vertical jumping performance, the following suggestions for futher investigations are:

1. The incorporation of a larger sample population in an investigation similiar to that of this research could serve to further substantiate findings of this research or could refute the findings therein.

2. An investigation of the effects of isometric, isotonic, and combined isometric-isotonic programs of training on quadricep strength and vertical jumping performance, training and testing of the subjects in a squat type movement.

3. An investigation into the individual component functions of the Exer-Genie could be done to reveal the contributions of the isometric phase or the isotonic phase, and the combined isometric-isotonic movement.

4. A study could be done to investigate the relationship of maximum isometric strength to maximum isotonic strength.

CHAPTER I

INTRODUCTION TO THE INVESTIGATION

Introduction

With today's athletes and fitness minded population relying on muscular strength to accomplish the optimum in performance, the most efficient means of producing strength is constantly being sought. Among researchers, coaches, and athletic trainers, a controversy appears to exist as to the best method for the development of muscular strength. "All desire a system of training that will produce the most rapid increase in strength and muscle hypertrophy within a limited time period."[1]

Isotonics, isometrics, and combination isotonic-isometric devices have at one time or another been popular as systems for the development of muscular strength.

Although there have been few recorded facts, training using an isotonic principle has been in existance since antiquity. It was recorded that Milo of Crotona trained on scientific principles in the sixth century B. C.[2]

Athletes of all types have used isotonics systems in their training programs. Former Olympic decathloners, Bill

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[1] Patrick O'Shea, "Effects of Selected Weight Training Programs on the Development of strength and Muscle Hypertrophy," Research Quarterly, 37:96, March, 1966.

[2] Norman Gardiner, Athletes of the Ancient World (London: Oxford Press, 1930), pp. 53-54.

Tommey and Russ Hodge have employed systems of progressive resistance exercise in their training programs.[3] Weight training has been advocated as a supplement to the running programs of high school cross-country runners by Newton.[4] Isotonic systems of exercise have also been utilized by athletes of other sports.

Six to nine years ago, isometrics was a popular method of producing muscular strength. Isometrics received much publicity as a system that could strengthen the body with seconds of work each day.[5] A large amount of effort has been made in the past decade to interest the public in isometrics in various forms,[6] chief among these was the isometric method formulated by Charles Atlas known as dynamic tension.[7]

The Exer-Genie (isometric-isotonic device) reached its popularity in 1966 and 1967 as many professional and collegiate athletic teams employed the combination device to

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[3] Jim Murray, "Citius, Atius, Fortius," Mr. America All American Athlete. 9:50, February, 1968.

[4] Joseph Newton and Karl Schindl, The Long Green Line, Championship High School Cross-Country (Oak Brook, Illinois: All American Publishing Company, 1970), p. 130.

[5] Lawerence Galton, Outdoorsman's Fitness and Medical Guide (New York: Harper & Row, 1966), p. 75.

[6] Jay A. Bender, et al., "Isometrics: A Critique of Faddism Versus Facts," Journal of Health, Physical Education and Recreation, 34:21, June, 1968.

[7] Steven Bimingham, "Far Out Beyond Fitness," Sports Illustrated, 11:62, July 27, 1959.

produce gains in muscular strength.[8,9,10,11] By not having to change weight plates following each exercise, the Exer-Genie saved valuable practice time in addition to providing resistance through a full range of motion.

All three systems of producing muscular strength appear to have been widely used by coaches and athletes representing various physical activities. Research has been reported concerning the effectiveness of isometrics and isotonics; little research has been published concerning the Exer-Genie. Because little research has been published investigating these three forms of resistance exercise concurrently, a comparison of isotonics, isometronics (combination isometrics-isotonics), and isometrics, and their effects on quadricep strength and vertical jumping ability was deemed warranted.

The Problem

Statement of the Problem. The purpose of this study was to investigate the effects of isometrics, isotonics, and combined isometric-isotonics on quadricep strength and verti-

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[8] News Chronicle (Thousand Oaks, California), August 7, 1966, p. 4.

[9] Los Angles Times (Los Angles, California), August 25, 1966, Part III.

[10] Record-Courier (Kent, Ohio), September 15, 1967.

[11] G. A. Logan, et al., "Effects of Resistance Through a Throwing Range of Motion on the Velocity of a Baseball," Perceptual Motor Skills, 23:55, April, 1966.

cal jumping performance. More specifically, this investigation sought to:

1. Investigate any differences in treatment group quadricep strength that might occur after nine weeks of training with isometric, isotonic, and isometronic exercise programs.

2. Investigate any differences in treatment group vertical jump performance that might occur after nine weeks of training with isometric, isotonic, and isometronic exercise programs.

3. Investigate the effects of nine weeks of isometric, isotonic, and isometronic exercise on quadricep strength from T-1 to T-2.

4. Investigate the effects of nine weeks of isometric, isotonic, and isometronic exercise on vertical jumping performance from T-1 to T-2.

Scope of the Study. Twenty-four male students enrolled in Appalachian State University during the spring quarter of 1971 were used as subjects in this investigation. Twenty of the volunteers were students taking Physical Education 119 (Weight Training); the other four subjects were physical education majors. The subjects' ages ranged from 18.58 years to 25.50 years with the mean age of 19.77 years. Subjects were randomly assigned to one of three experimental treatment groups or to a control group.

Group I (N=5, Isotonics) trained with an isotonic, progressive resistance routine. The subjects trained with a weight boot performing three sets of quadriceps extension with each leg using the six repetition maximum.[12]

Group II (N=6, Isometric-Isotonic) trained with the Exer-Genie. The subjects performed three repetitions according to the following: The exercise was begun with an isometric contraction at 90 degrees of the knee extension concluded by an isotonic movement against progressive resistance through the full range of extension. Resistance was variable depending upon the individual subject.

Group III (N=7, Isometrics) trained utilizing an isometric resistance routine. The subjects performed a knee extension of six seconds duration at three positions with each leg: (1) 90 degrees, (2) 110 degrees, and (3) 130 degrees.[13] Each contraction was maximal.

Group IV (N=4, Control) participated only in the initial and the final testing periods.

All subjects trained twice weekly on Mondays and Wednesdays for nine weeks. Fridays were used as make-up days in the event that a subject missed a regularly scheduled class. The subjects trained during the allotted class

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[12] Richard A. Berger, "Comparative Effects of Three Weight Training Programs," Research Quarterly, 34:397, October, 1963.

[13] Gerald W. Gardner, "Specificity of Strength Changes of the Exercised and Non-Exercised Limb Following Isometric Training," Research Quarterly, 34:101, March, 1963.

period and were instructed not to participate in any resistive exercises which might have an effect upon the final results of the research. Testing occurred before training (T-1) and again at the conclusion of nine weeks of training (T-2).

Definition of Terms

Exer-Genie.[14] A device that allowed an isometric contraction and an isotonic contraction was the Exer-Genie. This device allowed the subject to determine the resistance in a matter of seconds.

Isometronic Contraction. The designation of an isometric contraction immediately followed by an isotonic contraction or an isotonic contraction immediately followed by an isometric contraction was an isometronic contraction.

Isometric Contraction. A muscular contraction in which the length of the working muscle remains constant is an isometric contraction.[15] It may be referred to as a static contraction.[16]

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[14] William H. Coulter, "Physical Development Program," (Charlotte, North Carolina), (mimeographed).

[15] Bender, loc. cit.

[16] Peter V. Karpovich, Physiology of Muscular Activity (Philadelphia: W. B. Saunders Company, 1966), p. 10.

Isotonic Contraction. A muscular contraction in which the length of the working muscle changes while the resistance remains the same is an isotonic contraction.[17] It may also be referred to as a dynamic contraction.[18]

Cable Tension Tests. Tests developed by Clarke and Peterson originally used for measuring the strength of abnormal muscle groups associated with orthopedic disabilities and later adapted for research were known as cable tension tests.[19]

Cable Tensiometer. An instrument originally designed to measure the tension of aircraft control cable and later adapted for use in measuring muscular strength was the cable tensiometer.[20]

Goniometer. The goniometer was an instrument consisting of a 180 degree protractor made of plexiglass with two 15 inch arms; the goniometer was used in the measuring of joint angles.[21]

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[17] Per-Olof Astrand and Kaare Rodahl, Textbook of Work Physiology (New York: McGraw-Hill Book Company, 1970), p. 70.

[18] Ibid., p. 73.

[19] H. Harrison Clarke, A Manual Cable Tension Strength Tests (Springfield, Massachusetts: Springfield College, 1953), p. 1.

[20] Ibid., p. 2.

[21] Ibid., p. 6.

Power. The ability of the individual to produce work per unit of time was power.[22]

Progressive Resistance. A training principle associated with isotonic work that allowed resistance to be increased as the working muscle increased its strength was known as progressive resistance.

Repetition Maximum (RM). The maximum amount of weight an individual can lift a designed number of times was the repetition maximum.

Limitations

1. The original cable broke and was not used in the testing. The replacement cable used did not meet the exact specifications as recommended by Clarke.[23]

2. The cable tensiometer was not calibrated, although consistancy in the tensiometer measurements was demonstrated by rank-order correlations.

3. Two subjects received injuries unrelated to the training program and were dropped from the study.

4. Two members of the isotonic group were not used in the final data analysis because of their abnormal reaction to the training program. Each made very large declines

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[22] Herbert A. deVires, Laboratory Experiments in Physiology of Exercise (Dubuque, Iowa: William C. Brown Company, Publishers, 1971), p. 1.

[23] Clark, loc. cit.

in quadricep strength which could have been due to many factors.

5. The limited sample size could have had an adverse effect on the statistical analysis.

6. There were no controls over the subjects' outside activities, diet, and daily habits.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Much research concerning many aspects and related ideas of strength has been published within the last two decades. Although much has been published during that period, questions concerning the development of strength occurred as early as 1897.[1]

Researchers realized that muscle groups respond to an increase in work load by a change in size and/or strength. Morpurgo of the Pathological Institute of the University of Siena wrote, ". . . as certain as is the fact that the mass of voluntary muscle increases in response to greater work, so uncertain is our knowledge concerning the mechanism that underlies this enlargement.[2]

In 1921 three students, Elbel, Brunsberg, and Hughes, at Springfield College conducted research that revealed

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[1] B. Morpurgo, Uber Activitats, "Hypertrophie de Willkurlicken Muskeln," Virchows Archiv, 150:522-544, 1897, cited by Authur H. Stienhaus, "Strength from Morpurgo to Muller - A Half Century of Research," Journal of the Association for Physical and Mental Rehabilitation, 9:147, September-October, 1955.

[2] Ibid.

strength could be increased by a short, static contraction.[3] Later, Petow and Siebert[4] showed that skeletal muscles hypertrophy in proportion to the intensity of the stimulus. The researchers demonstrated this theory with the utilization of frog muscle and isometric contractions.

From the early research, questions were raised which led to a number of experiments concerning the development of muscular strength. Much of today's literature concerning various method (isometric, isotonic, and isometric-isotonic) for developing strength and vertical jumping performance is conflicting.

Development of Strength

Isometric Strength. Some earlier research on strength development dealt with that strength which would occur as the result of static muscular contractions. In the early 1950's Hettinger and Muller[5] reported that the training stimulus need not be maximal in order to derive maximum

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[3] Philip J. Rasch, "Isometric Exercises," in E. Jokl and E. Simon, eds., International Research in Sport and Physical Fitness. (Illinois: Charles C. Thomas, 1964), p. 415.

[4] H. Petow and W. Siebert, "Studien Uber Arbeitshypertrophy des Muskels," S. Klin. Med., 102:427-433, 1925, Stienhaus, op. cit., p. 148.

[5] T. H. Hettinger and Erich A. Muller, "Muskelleistung und Muskeltraining," Arbeitsphysiologie, 15:111-126, 1953 cited by Erich A. Muller, "The Regulation of Muscular Strength," The Journal of the Association for Physical and Mental Rehabilitation. 28:42, March-April, 1957.

benefits two thirds of the maximal contraction had almost the same effects as a near maximal contraction in the development of muscular strength. The two Germans stated that the threshold of the training effect was between three and four tenths of the maximal muscular contraction.

Concerning an effective training threshold, Muller and Rohmert[6] reported that repetitive exercise produced a more significant increase in muscular strength than a single isometric effort. The results obtained by Myers[7] in research conducted at the State University of New York at Buffalo tended to agree that repetitive exercise was more effective in developing muscular strength than a single isometric effort. He revealed that a program utilizing 20 six-second bouts of isometric contraction was more beneficial than a program using three six-second isometric contractions in the development of strength of elbow flexion.[8]

Cotton[9] questioned the effects of varied percentages of the single maximal isometric contraction on the strength

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[6] Erich A. Muller and W. Rohmert, "Die Geschwindigbeit der Muskel Kraft-Sunahume Bei Isometrischem Training," Arbeitsphysiologie, 19:401-419, 1963, cited by Carlton Myers, "Effect of two Isometric Routines on Strength, Size, and Endurance in Exercised and Non-Exercised Arms, "Research Quarterly 38:451, October, 1967.

[7] Carlton Myers, op. cit., p. 440.

[8] Ibid.

[9] Doyice Cotton, "Relationship of the Duration of Sustained Voluntary Isometric Contraction to Changes in Endurance and Strength," Research Quarterly, 38:366,68,70 October, 1967.

of left forearm flexors. Four groups (N=24) were trained at 25%, 50%, 75%, and 100% of the individual maximal contraction. All groups except the group training at 25% of the maximal contraction improved significantly in strength. Although this study was not compared with others investigating the effects of repetitive isometric exercise on muscular strength, it did not refute the validity of the single contraction as a sufficient training stimulus to promote an increase in strength.

Wickstrom[10] presented research which tended to dispute the ideas of the single isometric contraction as an effective method of producing muscular strength. He trained the right and left hand grips of 26 graduate students daily for a period of six weeks and reported no significant gains in strength. All subjects trained utilizing a maximum isometric contraction of the grip of two seconds duration.

Questioning the differences between the single and repetitive methods of isometric exercise, Morehouse[11] found no significant differences in the development of strength among subjects who trained with one, three, five, or ten isometric contractions per training session. Training occurred four times weekly for nine weeks.

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[10] Ralph L. Wickstrom, "An Observation of the Isometric Contraction as a Training Technique," Journal of the Association of Physical and Mental Rehabilitation, 12:162, September-October, 1958.

[11] Chauncey A. Morehouse, "Development and Maintenance of Isometric Strength of Subjects with Diverse Initial Strengths," Research Quarterly, 38:456, October, 1967.

Baley[12] conducted research at the University of Connecticutt on 104 students in order to determine the effect of 40 isometric exercises on four measures of strength. The students made significant strength improvements in the right and left grip, in the leg lift, and the back lift.

Hislop[13] trained 91 subjects with elbow flexion utilizing various isometric routines. The subjects were distributed into 14 exercise groups: eight performed maximally each bout, four at 75% of the maximal strength, and two at 67% of the maximal strength. The frequency of training was two bouts daily, one bout daily, three bouts weekly, and two bouts weekly. Those groups training maximally significantly exceeded in strength gaines of those groups training submaximally. The greatest increase in strength was noted in the group performing two maximal 15-second isometric bouts daily.

Isotonic Strength. Much of the research concerning the development of strength through the use of isotonic programs has dealt primarily with the establishment of the optimum number of repetitions and sets of repetitions for maximal gains in muscular strength.

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[12] James A. Baley, "Effects of Isometric Exercises Done with a Belt Upon the Physical Fitness Status of Students in Required Physical Education Classes," Research Quarterly, 37:291-92, 300, May, 1966.

[13] Helen J. Hislop, "Quantitative Changes in Human Muscular Strength During the Isometric Exercise," Journal of the American Physical Therapy Association, 43:21-38, 1963.

Berger,[14] in 1962, researched the question of the optimum number of repetitions for strength development when training with one bout of an isotonic progressive resistance exercise. Berger trained 199 male college students three times weekly for 12 weeks. The subjects trained with two, four, six, eight, and 12 repetitions of the bench press. Although all groups differed significantly, those training with four, six, or eight repetitions had higher mean gains than those subjects training with two, ten, and 12 repetitions.

After training 79 male college subjects with varying percentages of the 1-RM for the deep knee bend, Berger[15] concluded that significant gains in strength could occur after two weeks of training twice weekly with at least two-thirds of the 1-RM for one set and a third session during the week using one maximal isotonic effort.

In comparisons between resistance load and strength improvement, Berger[16] indicated that training with 90% of the 10-RM was just as effective as training with the 10-RM. Berger's 1962 and 1965 research confirmed that progressive

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[14] Richard A. Berger, "Optimum Repetitions for the Development of Strength," Research Quarterly, 33:335,338, October, 1962.

[15] Richard A. Berger, "Comparison of the Effect of Various Weight Training Loads on Strength," Research Quarterly, 36:146, May, 1965.

[16] Richard A. Berger, "Comparison Between Resistance Load and Strength Improvement," Research Quarterly, 33:637, December, 1962.

resistance exercise need not be maximal in order to reach a training threshold.

Berger and Hardage[17] further demonstrated that progressive resistance training need not be maximal in order to produce optimum strength gains. The results concurred with other research dealing with the effectiveness of sub-maximal training loads. The two researchers trained 50 male college students in two groups. One group trained with ten repetitions using the 10-RM for one set of the bench press; the other group employed ten repetitions with each repetition being near the 1-RM. A data analysis indicated that both groups improved significantly in strength although Group II had a statistically higher mean ($p < 0.05$).

Concerning strength gains among beginning weight lifters, Withers[18] trained 55 Washington State University freshmen twice weekly for nine weeks using three times 7-RM, four times 5-RM, and five times 3-RM exercising with the biceps curl, bench press, and the squat. All three training schedules resulted in significant increases in strength beyond the 0.01 level; however, there were no significant differences among the three experimental groups. Withers went on to state that weight lifters would probably record

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[17] Richard A. Berger and Billy Hardage, "Effect of Maximum Load for Each of Ten Repetitions on Strength Improvements," Research Quarterly, 28:717, December, 1967.

[18] R. T. Withers, "Effect of Varied Weight Training Loads on the Strength of University Freshmen," Research Quarterly, 41:110,113, March, 1970.

the most improvement in strength when training with three times 5-RM; beginning weight lifters would benefit the most from a schedule of four times 6-RM.

Berger[19] questioning the effectiveness of three programs of resistance exercise, employed the following training routines: three times 6-RM, six times 2-RM, and three times 10-RM. Forty-eight subjects were trained with the bench press, three times weekly for nine weeks using three routines. All groups improved significantly in strength (measured by the 1-RM bench press) beyond the 0.001 level with no apparent differences among the groups.

In an earlier experiment, Berger[20] demonstrated that three times 6-RM was a significantly more effective training stimulus than seven other combinations of sets and repetitions when training was extended over a period of 12 weeks.

O'Shea[21] found that training with three sets of two to three repetitions increased static strength more significantly than training with three sets of nine to ten repetitions or three sets of five to six repetitions; however, when a dynamic strength test was utilized, the group training

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[19] Richard A. Berger, "Comparative Effects of Three Weight Lifting Programs," Research Quarterly, 34:396-398, October, 1963.

[20] Richard A. Berger, "Effects of Varied Weight Training Programs on Strength," Research Quarterly, 33:168, 170, 180, May, 1962.

[21] Patrick O'Shea, "Effects of Selected Weight Training Programs on the Development of Strength and Muscle Hypertrophy," Research Quarterly, 37:95-102, March, 1966.

with three sets of five to six repetitions had the largest mean improvement.

Forty-eight college students were trained three times weekly for nine weeks utilizing the following routines: six times 2-RM, three times 6-RM, and three times 10-RM. In this study, Berger[22] found that training with heavy loads for few repetitions and numerous sets does not improve strength as much as with lighter loads for more repetitions and fewer sets.

MacQueen,[23] in examining various methods for the optimum development of power, suggested that the beginning weight for any exercise should never be less than that which can be lifted in the 10-RM. The weight should be increased between each set and the repetitions decreased for each succeeding set; at the end of the total exercise, the weight should be such that it could be lifted only once. The MacQueen technique revealed a reversal in the technique prescribed by DeLorme and Watkins. DeLorme and Watkins[24] found that muscular strength was best increased when the subject

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[22] Richard A. Berger, "Comparative Effects of Three Weight Training Programs," Research Quarterly, 34:396-398, October, 1963.

[23] I. J. MacQueen, "Recent Advances in the Technique of Progressive Resistance Exercise," British Medical Journal, 4898:1197, November, 1954.

[24] Thomas DeLorme and Authur Watkins, "Technics of Progressive Resistance Exercise," Archives of Physical Medicine, 29:264, May, 1948.

began the exercise with one-half the 10-RM and then in the third set increased the resistance to the 10 repetition maximum.

Isometric-Isotonic Comparison. Darcus and Salter[25] conducted research in which 12 subjects were trained isotonically and isometrically for "five or six days" in pronation and supination of the hand. After that period of time, ten of the subjects (six isometric; four isotonic) continued to train in their respective groups five days weekly until 20 to 28 sessions had been completed. The experiment revealed that short term isometric (five or six days) training had a variable effect on the maximum dynamic force that could be exerted. Over a longer period of time, the static training revealed a greater increase in isotonic strength. Isometric training produced a 26.51% increase in strength the first week; over the longer period the isometric group improved 32.77% in isotonic strength. The isotonic group improved 97.51% in the short term training session and 133.08% over the longer training period in isometric strength. It was concluded that:

> both isometric and isotonic training lead to an increase in muscle strength whether the criterion is the maximum isometric force that can be exerted or the maximum distance through which a heavy load can be lifted. In general,

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[25] H. D. Darcus and Nancy Salter, "The Effect of Repeated Muscular Exertion on Muscle Strength," Journal of Physiology, 129:327,328,330, August 29, 1955.

dynamic training causes a greater percentage improvement than static training.[26]

Dunn[27] trained six groups of subjects (N=112), three groups isometrically and three groups concentric-eccentrically using varying percentages of the subject's maximal isometric contraction. All groups made significant gains in strength of the left forearm flexor muscles; however, no significant differences existed between the mean gains of the six exercise groups. With the non-significance between the isometric and the concentric-eccentric training groups, the results were contradictory to the results obtained by Darcus and Salter.

In another project comparing the effects of isometric and isotonic training on muscle strength, Salter's[28] results concurred with earlier research by Darcus and Salter concerning the non-significance of difference between isometric and isotonic methods of training. Twenty subjects were trained in the supination of the left hand. The subjects were divided into two groups, one training isometrically and the other isotonically. Training was carried out four times

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[26] Darcus and Salter, op. cit., p. 333.

[27] John H. Dunn, "The Effects of Selected Intensities of Isometric and Concentric-Eccentric Exercises on the Forearm Flexor Muscles on Strength, Endurance, and Girth," in T. K. Cureton (ed.), Abstracts of Graduate Thesis in Physical Education, Recreation and Health Education, Vol. 8 (Urbana, Illinois: College of Physical Education, 1959).

[28] Nancy Salter, "The Effect of Muscle Strength on Maximum Isometric and Isotonic Contraction," Journal of Physiology, 130:109, 111, October, 1955.

weekly for four weeks; both groups performed 30 contractions of four seconds duration each training session. The isometric group performed with a resistance equal to 75% of the maximum isometric strength. Although both groups made significant improvements in strength, there was no statistical difference between the two groups.

Research conducted in 1966 by Burnham[29] revealed no significant difference between isometric and isotonic exercise in terms of a method of producing gains in strength. Burnham stated that a gain in strength would occur provided the training effort was above the training threshold regardless of whether training was isometric or isotonic.

Ninty-six male college freshmen were trained (three experimental groups) isotonically with the supine press, isometrically with an extended supine press, and isometrically with a flexed supine press. In this study, Bergerson[30] found that static strength measured at either an extended or flexed position can be increased significantly by training isometrically, at either a flexed or extended position or by training isotonically using sub-maximal loads.

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[29] Stanley Burnham, "A Comparison of Isometric and Isotonic Exercise in the Development of Muscular Strength for Individuals with Different Levels of Strength," (unpublished Doctoral dissertation, L. S. U., Baton Rogue, La., 1966), p.32.

[30] Phillip C. Bergerson, "The Effect of Static Strength Training at Various Positions and Dynamic Strength Training Through a Full Range of Motion of Strength, Speed of Movement, and Power," (unpublished Doctoral Dissertation, L. S. U., Baton Rogue, La., 1966), p. 32.

Robinson[31] trained 80 freshmen enrolled in required physical education courses at Fayetteville State University. One group (N=40) trained with a battery of 15 isometric exercises; the other group (N=40) trained with a varied battery of progressive resistance exercises. At the conclusion of training, the Larson Muscular Strength Test showed no significant differences in strength gains resulting from the isometric and the isotonic routines.

Bates[32] trained 108 male college students isometrically and isotonically with various phases of the bench press (one third, two thirds, and full press). All six groups showed a significant increase in static strength, although there were no significant differences noted among the groups due to isometric or isotonic training.

Baer et. al.[33] trained six groups of subjects daily for four and six week periods. Exercise groups were classified as follows: high resistance isotonic with 10 contractions per minute, high resistance isotonic with 30 contrac-

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[31] Frank P. Robinson, "A Study of the Effect of Isometric and Isotonic Exercises on the Development of Muscular Strength," (unpublished Master's thesis, North Carolina College, Durham, N. C. 1968), p. 66.

[32] James D. Bates, "The Effects of Static and Dynamic Strength Training and Position of Exercise on the Acquisition of Strength, Speed of Movement, Reaction Time, and Endurance," (unpublished Doctoral dissertation, Louisana State University, Baton Rogue, La., 1967), pp. 41-46, 75-77.

[33] Adrian D. Baer et. al., "Effects of Various Exercise Programs on Isometric Tension, Endurance, and Reaction Time in the Human," Archives of Physical Medicine, 36:495-502, August, 1955.

tions per minute, low resistance complex motion with 10 contractions per minute and isometric with 30 contractions per minute. Significant increases in isometric tension were noted in the isometric group and the isotonic groups training with high resistance at 10 contractions per minute. Isotonic contractions against high resistance performed at a rate of 30 contractions per minute produced no significant gains in isometric tension.

Exer-Genie (Isometric-Isotonic). Little research has been completed in which the Exer-Genie was tested; however, several reports have been published in which the isometric-isotonic principle was used as an integral part of the research.

The value of the Exer-Genie as a means of developing elbow flexor strength in secondary school girls was observed by Long.[34] Long used 22 freshman and 23 sophomore girls at the Holy Names Academy as subjects. Each girl trained using five repetitions with each arm. When the girls increased to ten repetitions, the resistance was increased. The experimental group made a significant strength gain at the 0.01 level of confidence.

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[34] Pamela E. Long, "The Use of the Exer-Genie in the Development of Elbow Flexor Strength," (unpublished Master's thesis, Washington State University, Pullman, Washington, 1967) pp. 2,9, 18.

Waddle[35] did a study which compared the effectiveness of the Exer-Genie with an isometric program in the development of muscular strength. The Exer-Genie program consisted of ten exercises; the isometric program consisted of a nine exercise routine. A statistical analysis revealed that no significant differences existed between the two training groups.

Fischer[36] completed a study comparing three types of training in which he employed the isometric-isotonic principle, although the Exer-Genie was not used. Ninth grade junior high school boys were trained with isotonic, isometric and power (isotonic-isometric) routines. The subjects exercised daily for nine weeks training arm flexion and extension, forearm flexion, and thigh and leg extension. Strength gains in the isotonic and the power groups were more significant than strength gains resulting from isometric training.

Again the effectiveness of isometrics, isotonics, and isometric-isotonic training programs were investigated.

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[35] Benjimen Waddle, "A Study Comparing the Effectiveness of a Training Program Utilizing the Exer-Genie With Two Conventional Training Programs on the Development of Muscular Strength and Cardiovascular Endurance," (unpublished Doctoral dissertation, Florida State University, Tallahassee, Florida, 1967), pp. 107-110.

[36] Harold J. Fischer, "Comparison of Isotonic, Isometric, and Power Training in the Development of Muscular Strength," (unpublished Doctoral dissertation, University of Texas, Austin, Texas, 1968), pp. 5,6,112.

Henrickson[37] found that all three experimental groups gained significantly in static strength in a lower knee position of the dead lift. Henrickson found non significant differences among the experimental groups which agreed with results obtained by Fischer.

Employing three systems of training (dynamic, static, and combination isometric-isotonic), Belka's[38] analysis of data revealed no significant differences among the three groups in reference to post mean differences in static strength. However, when a dynamic strength test was used, the isotonic group was significant.

In research involving the Exer-Genie, Halpren[39] trained two groups of ninth grade boys with an isometric-isotonic (Exer-Genie) squat and another group with progressive resistance squats. When the post means of the leg strength were compared, the Exer-Genie group was significantly different from the isotonic group whether strength was measure isotonically or isometrically.

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[37] Guy R. Henrickson, "The Effects of Isotonic, Isometric, and Combined Isotonic-Isometric Resistance Programs on Back Strength," in T. K. Cureton (ed.), Abstracts of Grad-Thesis in Physical Education, Recreation and Health Education, Vol. 13, (Urbana, Illinois: College of Physical Education, 1966).

[38] David E. Belka, "Comparison of Dynamic, Static, and Combination Training on Dominant Wrist Flexor Muscles," Research Quarterly, 21:82,92, May, 1950.

[39] Larry M. Halpren, "The Effects of Muscular Strength Gained on Vertical Jump Performance," (unpublished Master's thesis, San Fernando Valley State College, California, 1968), p. 48.

Research using an isotonic-isometric quadriceps extension was done by Rose et al. Rose et al.[40] trained three groups of subjects after finding the maximum amount the quadriceps could lift from 90 degrees to 180 degrees and hold isometrically for five seconds. From this maximal value, they found that weight increments of one and one quarter pounds could be lifted and held at each exercise period until a plateau was reached. The final increases in strength varied among the subjects from 80% to nearly 400% of the initial strengths recorded.

In other research, Rose[41] trained 47 adults with unilateral injuries to the knee. The subjects trained with a knee extension followed by a five second isometric contraction with a one and one quarter pound increment each training session. The load remained constant and subjects were able to lift the increment until a maximal plateau was reached. The results were in concurrence with an earlier study by Rose.

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[40] Donald L. Rose et al., "Effect of Brief Maximal Exercise on the Strength of the Quadricep Femoris," Archives of Physical Medicine and Rehabilitation, 38:157-164, March, 1957.

[41] Donald L. Rose, "Brief Maximal Isotonic Exercises in the Treatment of Knee Injuries." Journal of the American Medical Association, 177:1673-1673, December, 1959.

Using male members of the medical detachment of the Valley Forge General Hospital, Lawerence et al.[42] compared a progressive weighted isometric (PWIE) and a progressive resistance exercise (PRE) in the development of muscular strength of the quadricep femoris. PWIE training was 10 weight isometric contractions of 30 seconds duration with a 15 second interval between contractions. The PRE group trained with one times 50% of the 10-RM, one times 75% of the 10-RM and one times the 10-RM. Subjects were tested with the 10-RM, ten repetitions of 30 second weighted isometric contractions, and a one six second isometric contraction. The training period extended over a four week period (19 exercise days). The PRE group increased 76% in quadricep strength; the PWIE group increase 62% over the four week period (maximal increments).

The effect of a maximum repetition push-up exercise training program (N=12) and a maximum repetition combination isometric-isotonic push-up program (N=11) on muscular endurance as measured by maximum repetition push-up performance was investigated by Barker.[43] Both groups made significant increases in endurance push-up performance ($p > 0.01$); al-

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[42] Mary S. Lawerence et al., "Comparative Increases in the Quadricep Femoris by Isometric and Isotonic Exercise and Effects on the Contralateral Muscle," Journal of the American Physical Therapy Association, 42:15-20, January, 1962.

[43] Jerry W. Barker, "Effects of an Isotonic and a Combination Isometric-Isotonic Exercise Training Program Upon Push-up Performance," (unpublished Master's thesis, Auburn University, Auburn, Alabama, 1968), pp. 54-55.

though the experimental groups were not significantly different, a trend in favor of the maximum repetitions group was established. The author attributed this to a learning effort in the actual push-up movement.

Alexander et al.[44] did a study in which 11 subjects trained with six prescribed exercises using the 10-RM using the Exer-Genie as the exercise device. Strength was indicated by scores on the Rogers Physical Fitness Index. The mean difference between the experimental group and the control group at post test was 10.136 units. The difference had a t value of 2.142 which indicated a significant difference between the two groups in favor of the experimental group.

Vertical Jump

Isotonic Development. Numerous studies have been done which have examined the effects of progressive resistance training programs on vertical jumping ability. Capen[45] trained two groups of subjects (N=42, N=29), one group with 14 barbell and dumbell exercises, the other with tumbling, running, hand combats, and conditioning gymnastics. The isotonic group had a 13.1% increase in the vertical jump,

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[44] John F. Alexander et al., "The Effects of a Four Week Exer-Genie Training Program on Certain Physical Fitness Components of Conditioned Male University Students," Research Quarterly, 39:16-17,24,

[45] Edward K. Capen, "The Effect of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, 21:82, 92, May, 1950.

the conditioning group had a 10.5% increase; the mean difference between the groups was non-significant.

Chui[46] in assessing the validity of a systematic weight training program on athletic power as indicated by the Sargent Jump, found that subjects (N=23) who trained with a systematic program of weight lifting improved in the Sargent jump 7.2 cm. after training two to three times weekly for 12 weeks. The results of the study indicated that a systematic weight training program would have a positive effect on jumping performances.

Using freshmen basketball players at Springfield College as subjects, Roberts[47] found no significant differences in vertical jumping gains resulting from regular basketball practice, a jumping exercise program, and a progressive resistance routine. Ness and Sharos[48] conducted an experiment which revealed that a weight training program of deep knee bends and toe raises produced significant increases in jumping ability when compared to the control group which engaged only in regular practice.

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[46] Edward Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, 21:188-189, 192, October, 1950.

[47] J. A. Roberts, "A Comparison of the Effectiveness of Two Methods of Training Upon the Jumping Ability of Basketball Players," (unpublished Master's thesis, Iowa State Iowa City, Iowa, 1966), pp. 4, 17.

[48] P. E. Ness and C. L. Sharos, "The Effect of Weight Training on Leg Strength and the Vertical Jump," (unpublished Master's thesis, Springfield College, Springfield, Mass., 1956), pp. 45-47.

Brown and Riley[49] training basketball players with isotonic heel raises, found that the experimental group increased 2.9 inches which was significant at the 0.01 level of confidence; the control group activity was non significant. Darling[50] completed a study comparing the isotonic heel raise (N=10) and the isotonic full squat (N=10) as methods of improving the vertical jump. Both groups revealed a significant gain (1.65 inches and 1.21 inches, respectively) after five weeks of training. No significant differences were found between the groups.

Aldrich[51] training an experimental group with the full squat and the heel raise obtained a 2.17 inch increase after training three days per week for six weeks; the control group increase was 0.27 inches. With a t value of 5.08, the increase noted in the experimental group was significant at the 0.01 level of confidence; the control group increase

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[49] R. J. Brown and D. R. Riley, "The Effect of Weight Training on Leg Strength and the Vertical Jump," (unpublished Master's thesis, Springfield College, Springfield, Mass., 1957), pp. 29-30, 36, 41, 42.

[50] D. E. Darling, "A Comparative Study to Determine the Effect of Heel Raise and Deep Knee Bend Exercises on the Vertical Jump," (unpublished Master's thesis, Springfield College, Springfield, Mass., 1960), pp. 23, 24, 32, 35.

[51] Everette A. Aldrich, "The Effects of Weight Training on the Vertical Jumping Ability of Springfield College Freshman Basketball Players," (unpublished Master's thesis, Springfield College, Springfield, Mass., 1958), pp. 28, 29, 45.

was non-significant. Hopkins[52] training basketball players isotonically (full squat and heel raise) found that starting with 50% of the body weight as the resistance would significantly increase performance on the Sargent jump after training five times weekly for five weeks.

Sloan[53] using 22 members of a football team as subjects investigated the effects of the half squat and the full squat as methods of increasing vertical jumping ability. One group (N=11) trained with the full squat, the other group (N=11) trained utilizing the half squat. Training took place three days weekly for five weeks. Both groups made significant increases in the vertical jump (1.3 inches, full squat; 2.3 inches, half squat).

Anderson[54] trained a group of five subjects for six weeks with a program of running, rope jumping, bleacher running, and volleyball play while wearing weighted ankle spats. Another group of five subjects functioned as a control.

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[52] Anthony B. Hopkins, "The Effect of a Weight Training Program on Vertical Jumping Ability," (unpublished Master's thesis, Springfield College, Springfield, Mass., 1960), pp. 27, 28, 45.

[53] Gary Sloan, "A Comparison of the Full Squat and Half Squat Techniques of Weight Training for Increasing Leg Strength and Vertical Jumping Ability," (unpublished Master's thesis, Springfield College, Springfield, Mass., 1959), pp. 50, 51, 52.

[54] K. A. Anderson, "The Effect of the Weight Anklw Spat on the Jumping Performance, Agility, and Endurance of High School Basketball Players," (unpublished Master's Thesis, University of Wisconsin, Madison, Wisconsin, 1961), pp. 48-51.

The weight group made a significant increase (1.37 inches) in the vertical jump when compared to the control group (-0.17 inches).

An isotonic routine (curls, presses, squat jumps, toe raises, flat foot squats, and donkey ride toe presses) was demonstrated by Holmes[55] to a significantly improve vertical jumping ability (3.01 inches). A group practicing vertical jumping improved non significantly (1.35 inches) as did the control group which had a non-significant improvement of 1.59 inches.

Williams[56] trained 27 volunteers of a beginning swimming class with three varied weight training programs. William's research revealed that subjects training with curls, presses, half squats, and toe raises (N=10) or half squats and toe raises (N=9) increased significantly in vertical jumping ability over the group that trained with curls and presses (N=8).

Isometric Development. In a study by Ball, Rich, and Wallis[57] 63 college men were randomly placed in either

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[55] J. K. Holmes, "The Relationship Between Weight Training and Vertical Jumping," (unpublished Master's thesis, Arkansas State College, State College, Arkansas, 1962), pp. 20-25, 29, 30.

[56] Clayton Williams, "The Effects of Weight Training Upon Vertical Jumping Ability," (unpublished Master's thesis, Fort Hayes Kansas State College, Fort Hayes, Kansas, 1965), pp. 1-3.

[57] Jerry Ball, George Q. Rich and Earl L. Wallis, "Effects of Isometric Training on Vertical Jumping," Research Quarterly, 35:233-34, October, 1964.

an experimental or a control group. The experimental group trained three times weekly for six weeks with on ten-second maximal isometric squat. Statistical analysis revealed that the experimental group did not improve (1.2 centimeters) significantly from T-1 to T-2.

Conflicting results were obtained by Callahan[58] when isometric training was compared with rebound tumbling on the trampoline and their effects on the vertical jump. Callahan found no significant differences between the two experimental groups after eight weeks of training five days weekly. Both groups improved significantly in the vertical jump (rebound tumbling, 1.1 inches; isometric training, 1.3 inches).

Baley[59] used 142 college students in research investigating the effects of isometric exercises on the physical fitness status of college students. Sixty-three subjects were in the control; 44 subjects in an experimental groups performed 40 isometric exercises three times weekly for eight weeks; and 35 subjects in an experimental group performed 40 isometric exercises twice weekly for eight weeks. Although improvements were made by both experimental groups

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[58] H. F. Callahan, "The Effects of Isometric Training and Rebound Tumbling on Performance in the Vertical Jump." (unpublished Master's thesis, Arkansas State College, State College, Arkansas, 1965), pp. 23-27, 32.

[59] J. H. Baley, "A Comparison of the Effects of Isometric Exercises Upon the Physical Fitness Status," Journal of Sports Medicine and Physical Fitness, 7:199, 202, 203 December, 1967.

in the vertical jump, Baley did not indicate any significance of improvement from 1 pre- to post-testing.

Lindeburg, Edwards, and Heath[60] revealed that one 15-second isometric inverted leg press training five days per week for six weeks did not lead to a significant increase in long jumping performance. A t value of 1.486 for the mean gain was non-significant. This research concurred with the results obtained by Ball and associates that isometric training did not improve vertical jumping ability.

Isotonic-Isometric Comparison. Fifty subjects were utilized by Rapp[61] as he compared the effectiveness of isotonic and isometric programs on the development of vertical jumping ability. Training for both groups was the full squat and the half squat exercises carried out over a seven week period five days per week. The isometrically trained group showed a non-significant gain of 0.38 inches in the vertical jump; the isotonically trained group showed a significant gain of 0.83 inches in the vertical jump.

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[60] Frank A. Lindeburg, Donald Edwards and William Heath, "Effect of Isometric Exercise on Standing Broad Jumping Ability," Research Quarterly, 34:478-482, December, 1963.

[61] D. H. Rapp, "The Effect of Isometric Exercise and Isotonic Weight Training on Leg Strength and Vertical Jumping Ability," (unpublished Master's thesis, University of Illinois, Urbana, Illinois, 1962), pp. 33-35.

In a similiar study, Berger[62] trained three experimental groups: Group I, 10-RM of the half squat; Group II, 50-60% of the 10-RM in jumping squats; Group III trained statically at two positions of knee flexion. Group IV trained with 10 vertical jumps weekly. Training took place three times weekly for seven weeks. There were significant differences between the mean increases of the dynamically trained groups and the statically trained group in favor of the dynamic group. Mean gains for Group I and Group II were significant with t values of 4.98 and 5.78, respectively. The mean gain of the isometric group was non-significant.

Exer-Genie. Halpren[63] trained 69 junior high school boys three times weekly. One group trained with a squat started at 90 degrees of extension with a six second isometric contraction followed by an isotonic movement through a full range of motion. An isotonic group performed three sets of 10 repetitions loaded for 50%, 75%, and maximum effort. The control group trained by vertical jumping only. A comparison of post-training group means were non-significant. Improvements were 6.62 inches, Exer-Genie; 1.05 inches, control; and 0.98 inches, isotonic.

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[62] Richard A. Berger, "Effects of Dynamic and Static Training on Vertical Jumping Ability," Research Quarterly, 24:420-423, December, 1963.

[63] Halpren, op. cit., p. 23-24,35.

Specificity of Training

As early as 1937 questions concerning the relationship of strength to activities involving other neuromotor skills was investigated. Rarick[64] found that general strength was not highly related to speed of performance as indicated by the poor relationship between general strength and the Sargent Jump.

In 1940 Larson[65] indicated that strength was more related to the ability of a muscle to register its strength on instruments without necessarily being able to lift the body weight or propel it upward. Larson stated that the vertical jump test was a test of the ability of the body to develop power relative to body weight of which strength was not a major factor.

Research by Henry and Whitely[66] tended to confirm Larson's hypothesis. They stated that neuromotor control patterns are probably specific, i.e., different control patterns are involved when the muscle is moving a limb than when the muscle is exerting simple static tension.

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[64] Lawerence Rarick, "An Analysis of the Speed Factor in Simple Athletic Activities," Research Quarterly, 8:105, December, 1937.

[65] Leonard A. Larson, "A Factor and Validity Analysis of Strength Variables and Tests with a Combination of Chinning, Dipping, and Vertical Jumping," Research Quarterly, 11:91, October, 1940.

[66] F. M. Henry and J. D. Whitely, "Relationship Between Individual Differences in Strength, Speed, and Mass in an Arm Movement," Research Quarterly, 31:24-33, October, 1950.

McClemments[67] trained 86 men twice weekly for 16 weeks to determine if a positive relationship existed between leg strength and power with power being the ratio of vertical jumping height and body weight. The experimental groups trained the following muscle groups: leg and thigh extensors, leg and thigh flexors and extensors, leg and thigh flexors, and general physical fitness. Results indicated that all experimental groups were not equally effective in the development of power; gains in strength were not related to gains in power.

Smith[68] administered a modified Sargent jump and leg strength test with a leg dynamometer to 70 college men. Results of correlations indicated that there was no relationship between the height jumped and either the strength/mass ratio or simple leg strength. The results seemed to support a hypothesis that strength measured statically is of a different neuromotor pattern from the neuromotor pattern involved during a movement such as vertical jumping. In 1963 Berger conducted research that concurred with the findings of Smith. Berger's[69] results showed that an increase in static strength was not accompanied by a corresponding

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[67] L. E. McClemments, "Power Relative to Strength of Leg and Thigh Muscles," Research Quarterly, 37:73-74,46, March, 1960.

[68] Leon E. Smith, "Relationship Between Explosive Leg Strength and Performance in the Vertical Jump," Research Quarterly, 32:406,408, March 1961.

[69] Berger, "The Effects of Dynamic and Static Training on Vertical Jumping Ability," loc. cit.

increase in vertical jumping ability. Berger cited specificity of training as a reason for the non-relationship. Also in 1963 Lindeburg[70] further substantiated the specificity of training theory when no correlation was found between static strength gained in an inverted leg press and long jumping ability. Again, specificity of training was stated to have been the probable cause for lack of correlation.

Berger[71,72] concluded that dynamic strength was more closely related to motor ability than was static strength.

Conclusion

Strength. Early research established that the muscle would respond to an increase in work load.[73,74,75] Later the idea was revealed that short, static muscular contractions would result in an increase in muscular strength.[76,77] Concerning this point, much controversy has

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[70] Lindeburg, loc. cit.

[71] Richard A. Berger and Leon D. Baschke, "Comparison of the Relationships Between Motor Ability and Static and Dynamic Strength," Research Quarterly, 38:144-146, March, 1967.

[72] Berger, "The Effects of Dynamic and Static Training on Vertical Jumping Ability," loc. cit.

[73] Morpurgo, loc. cit.

[74] Rasch, loc. cit.

[75] Petow and Siebert, loc. cit.

[76] Hettinger and Moller, loc. cit.

[77] Muller, loc. cit.

resulted from the research concerning the effects of isometric and isotonic training programs on the development of strength.

Authorities differed as to whether repetitive isometric training was more significant than the single isometric contraction in the development of strength. Various research results have shown that repetitive isometric exercise was more effective than the single isometric contraction; research has also supported the statement that there were no significant differences between the single and repetitive contraction method of producing strength.

Research concerning isotonic programs for developing strength seemed to deal with the question of establishing the optimum number of repetitions and sets for the development of muscular strength. Different combinations of repetitions and sets have produced significant gains in muscular strength. When comparing the differences obtained as a result of training with isometrics or isotonics, no significant differences were found between the two methods.

The Exer-Genie (isometric-isotonic device) was found to be of value as a means of training for increased muscular strength. When compared with other types of training, the Exer-Genie or the isotonic-isometric principle was not significantly different from other training routines except in one study.

Vertical Jump. The use of progressive resistance exercises in research designs has lead to a number of studies which have resulted in significant increases in vertical jumping ability.

Of the research reviewed concerning isometric development of vertical jumping ability, most results have concluded that various isometric routines would not lead to a significant increase in vertical jumping ability. One case was reviewed in which vertical jumping was improved as a result of an isometric training program.

When isotonic routines were compared with isometric programs in the development of vertical jumping ability, the isotonic routines were demonstrated to be significantly superior to isometric programs. In the only case reviewed concerning the effects of the Exer-Genie on the vertical jump the Exer-Genie was found to be of value in the development of vertical jumping ability.

Specificity of Training. Research reviewed by the author supports the hypothesis that strength gained statically involved different neuromotor patterns than the neuromotor patterns of other skills or movements. In the literature reviewed, static training did not result in significant gains in vertical jump performance.

CHAPTER III

METHODOLOGY

Introduction

A review of the literature indicated that by utilizing either an isometric, isotonic, or isometronic (combined isometric-isotonic training program, one could significantly increase strength. Isotonic training was found to be of significant value in the development of vertical jumping performance. There did seem to be a controversy as to whether isometrics or isotonics was more significant in developing muscular strength. There were relatively few studies which involved the Exer-Genie or the isometronic principle in which the device was compared with other means of developing strength and vertical jumping ability. Because little or no research has been done investigating the effects of isometrics, isotonics, and an isometric-isotonic device on quadricep strength and vertical jumping performance, this research was deemed warranted.

Subjects

Twenty-four male students at Appalachian State University were used as subjects for the study during the spring quarter of 1971. Twenty of the subjects were enrolled in a

weight training course, Physical Education 119; four other subjects were physical education majors. The subjects' ages ranged from 18.58 years to 25.50 years with a mean age of 19.77 years. The 24 subjects had a mean weight of 168.77 pounds with a range of 134.50 pounds to 236.25 pounds. The subjects' heights ranged from 65.00 inches to 73.50 inches; the mean height was 70.03 inches. The subjects were randomly assigned to one of four groups, isometrics, isotonics, combined isometric-isotonics, or a control group.

Experimental Treatments

Isotonic Training. Group I (N=5) trained with an isotonic progressive resistance program utilizing the 3 X 6-RM[1] during extension of the knee. The resistance was provided by means of a weight boot. Whenever the subject was able to complete ten repetitions on the final set, five pounds of resistance was added to the boot. See Figure 1.

Isometric-Isotonic Training. Group II (N=6) trained with a combination isometric-isotonic program in which the resistance was provided by means of an Exer-Genie. The subjects performed three repetitions of the following on each leg: an isometric contraction at 90 degrees of knee extension immediately followed by an isotonic movement against resistance through the full range of extension.

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[1] Berger, "Comparative Effects of Three Weight Lifting Programs," loc. cit.

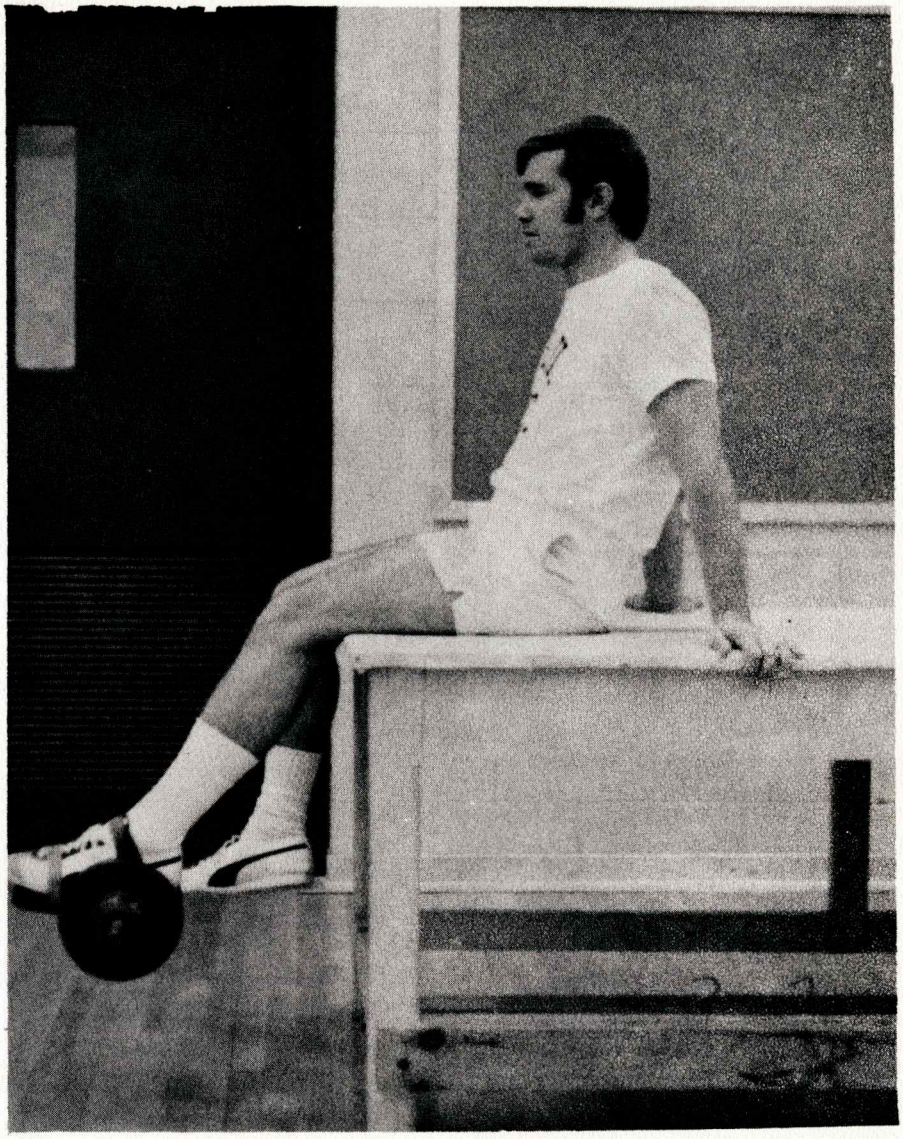

FIGURE 1

ISOTONIC KNEE EXTENSION WITH
WEIGHTED BOOT

When each subject felt the repetitions had become less taxing, the resistance was increased one unit. See Figures 2 and 3.

Isometric Training. Group III (N=7) trained utilizing an isometric resistance program. The subjects performed a knee extension contraction of six seconds duration with each leg at the following angles: (1) 90 degrees, (2) 110 degrees, and (3) 130 degrees of knee extension.[2] Each subject was instructed to make a maximal contraction each time. Thirty seconds was given between each contraction. See Figure 4.

Control Group. Group IV (N=4), participated only in the initial and the final testing periods. The control group was instructed not to engage in any resistive exercises.

Training Schedule

The subjects trained twice weekly (Mondays and Wednesdays) for nine weeks. A third day (Fridays) was used as a makeup day for those subjects who failed to attend either of the two regularly scheduled training days. The subjects trained during the class period and were instructed not to engage in any other training. Motivation for the subjects was provided in the form of the grades received for the course (P.E. 119) and encouragement from the principal researcher.

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[2] Gardner, loc. cit.

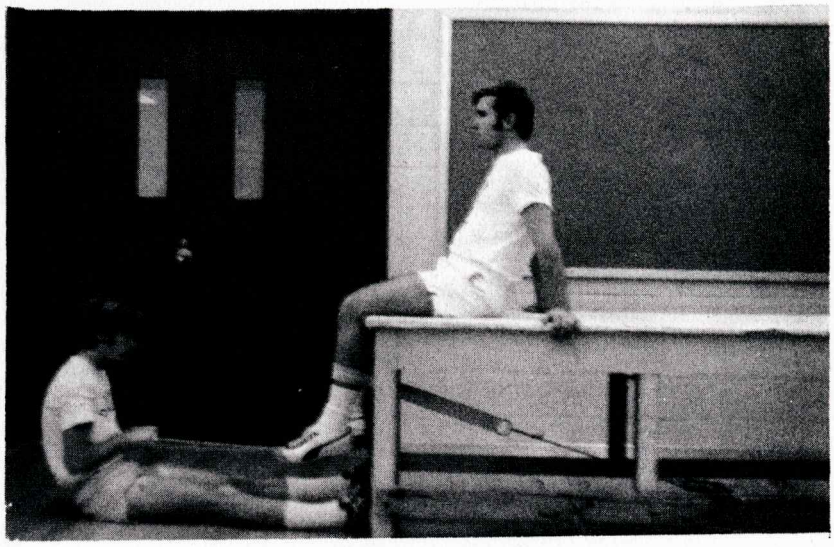

FIGURE 2

ISOMETRIC PHASE OF KNEE EXTENSION
DONE WITH EXER-GENIE

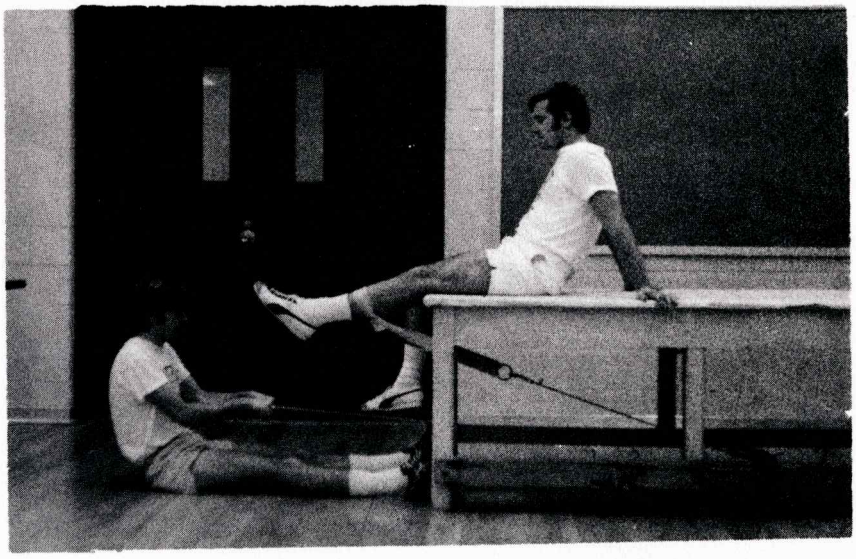

FIGURE 3

ISOTONIC PHASE OF KNEE EXTENSION
DONE WITH EXER-GENIE

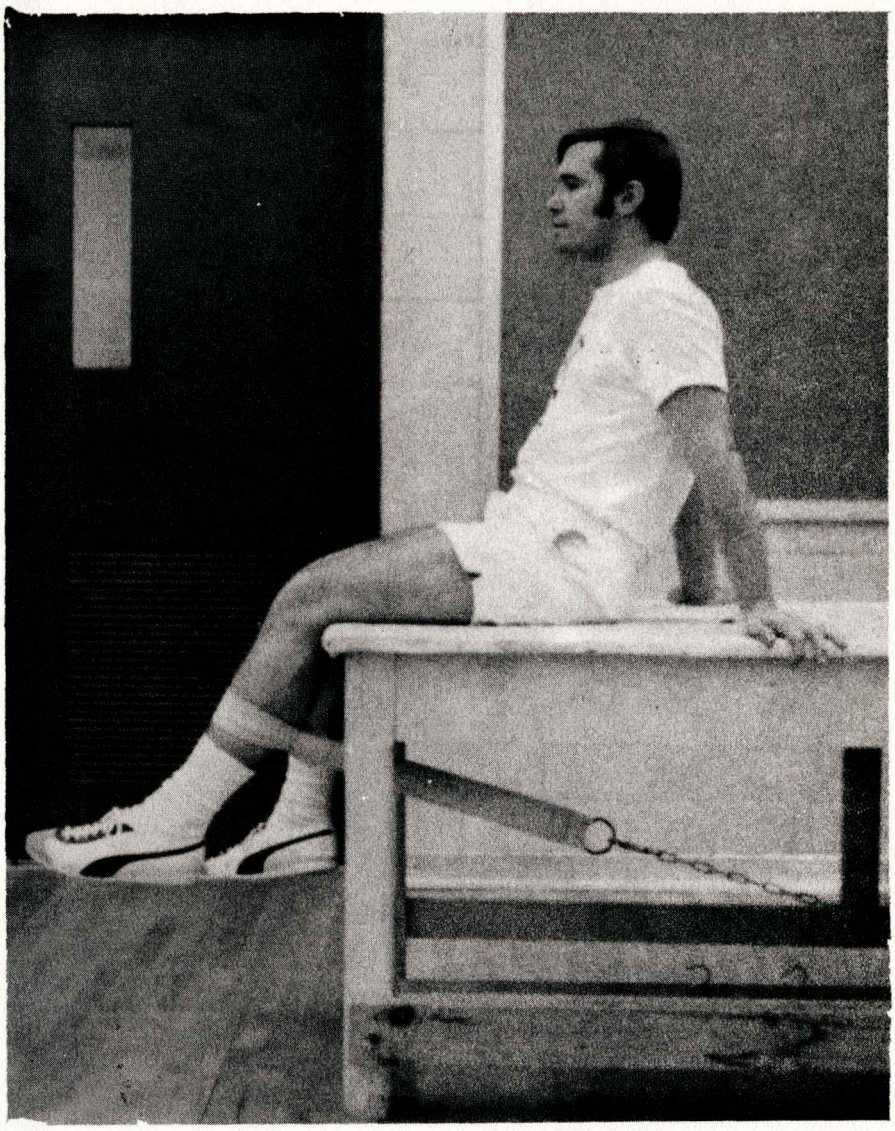

FIGURE 4

ISOMETRIC KNEE EXTENSION

Description of Tests

Testing Periods. Testing took place immediately prior to training (T-1) and again after nine weeks of training (T-2). All testing was done during the class period.

Quadricep Strength Test. Tests were conducted using a cable tensiometer to measure the strength of the left and right quadricep according to procedures established by Clark.[3] The subjects were given three trials with each leg; the maximum reading for each of the subjects was taken as the final reading to be recorded. See Figure 5.

The subject assumed a sitting position leaning backward with the hands grasping the side edges of the table. A goniometer was used to position each leg at 115 degrees of extension. Precautions were taken to insure that the subject did not lift with the buttocks or flex with the arms. The objectivity coefficient for the knee extension tests as stated by Clark[4] was 0.94.

Vertical Jump Test. The purpose of this test was to test the ability of the body to develop power relative to its body weight.[5] Each subject, according to the technique de-

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[3] Clark, loc. cit.

[4] Ibid.

[5] Carlton Myers and Erwin Blesh, Measurement in Physical Education (New York: The Ronald Press, Company, 1962), p. 195.

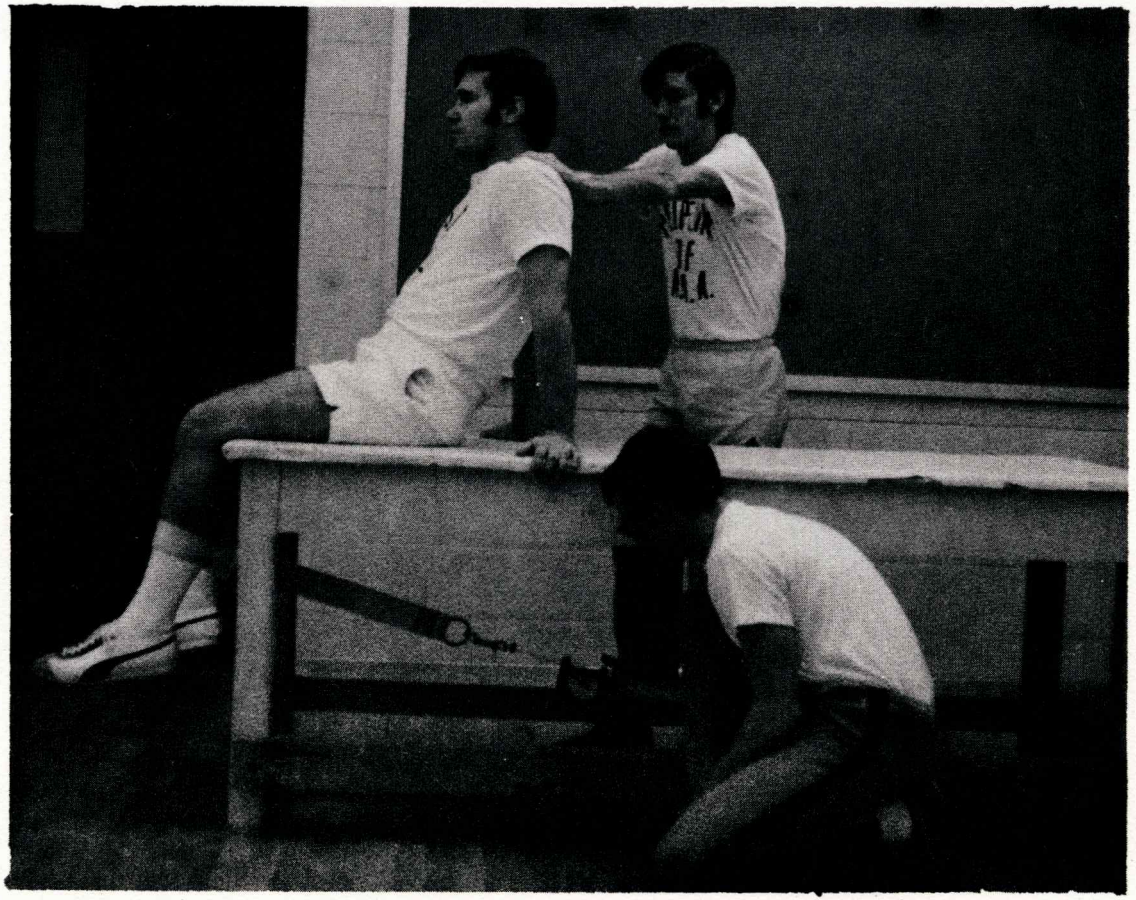

FIGURE 5

CABLE TENSION TEST OF QUADRICEP STRENGTH

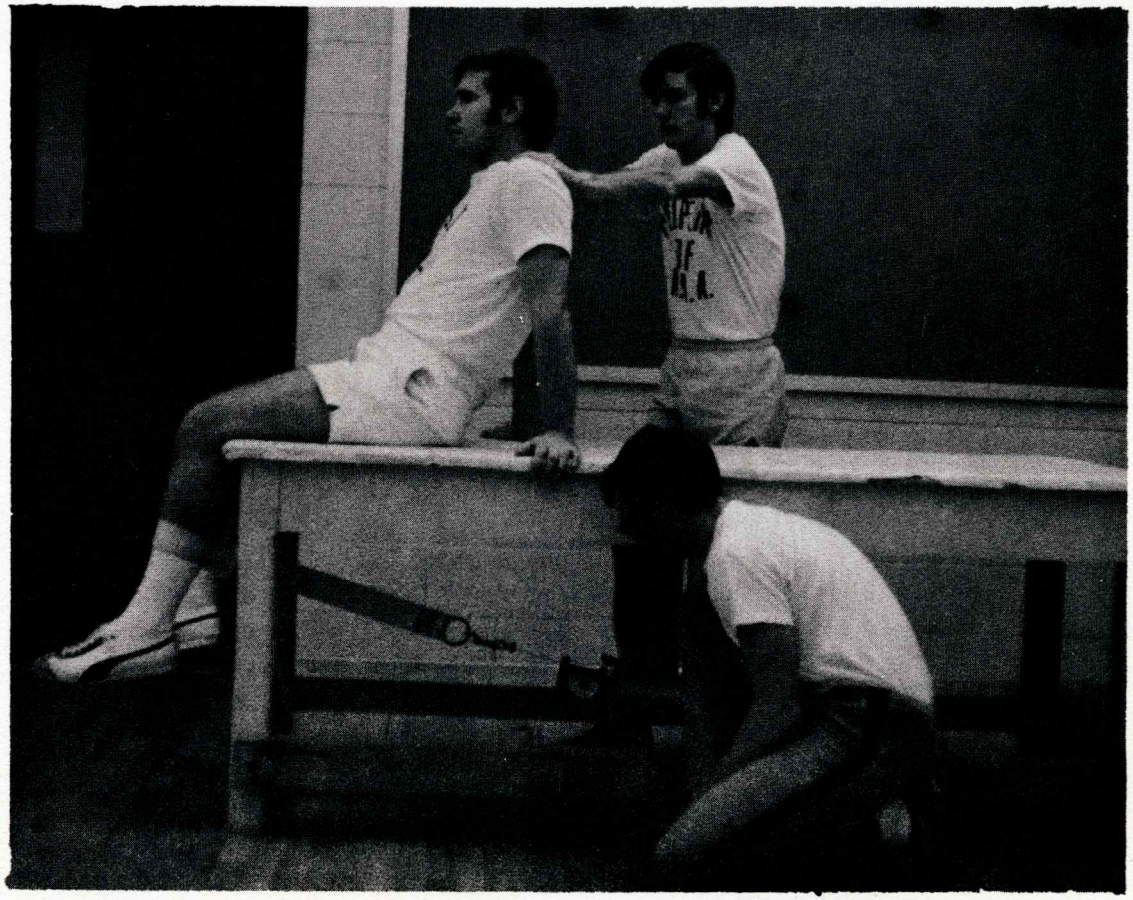

FIGURE 5

CABLE TENSION TEST OF QUADRICEP STRENGTH

scribed by Myers and Blesh,[6] stood with his side to the jumping board. With the feet flat on the floor, the subject then reached as high as possible to determine the arm reach. After having chalked the fingers, the subject, swinging both arms upward, jumped vertically to his fullest extent. The difference between the standing arm reach and that point touched at the highest point during the jump was the distance noted as the vertical jump. The vertical jump test was taken without any preliminary movement such as hopping or stepping. The best of three trial jumps was recorded. Each jump was recorded to the nearest one half inch.

Statistical Analysis

Test-Retest Reliability. To insure a high degree of reproducibility in the testing procedures, test-retest reliability coefficients were computed for the quadricep strength tests and the vertical jump tests. Subjects were tested on two successive weeks with the two tests. To assess the reliability, rank-order correlations were calculated.

Treatment of the Data. The data was coded and punched on computer cards. An I. B. M. 1130 computer analyzed the data using an analysis of covariance (ANCOVA) program developed by Dr. M. C. Carter, statistical consultant at Appalachian State University. In addition to performing the

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[6] Ibid.

analysis, the program also produced group means, variances, regression coefficients, and standard deviations.

Analysis of covariance is a technique for analyzing data when experimental units within treatment groups are assumed to be heterogeneous and a variable (covariable or concomitant variable) thought to explain this heterogeniety is measured in conjunction with the response. Therefore, information is available to explain the variation in the data; i.e., the variation due to groups (explained by the exercise treatments) and within group heterogeniety (explained by the covariable).

Under usual circumstances, one finds that the heterogeniety within groups is statistically similiar and that the responses can be adjusted for the covariable effect. The subsequent analysis of variance (ANOVA) on the treatment groups is supposedly free of any effects explained by the covariable, i.e., one gets a pure measure of the treatment effects.

If the situation arises that the four experimental groups do not have a statistically similiar level of homogeniety, then there is no valid way to compare all the treatments. The basis for this situation is that there is no statistical method by which the groups can be adjusted to the same baseline or starting point. If such cases do occur, each group must be analyzed singly or, at best, some

subset of the treatment groups with statistically similiar levels of homogeniety can be compared.[7]

The concept of the ANCOVA arose in diet experiments on swine.[8] Since it was impossible to start all the swine in the diet groups at the same weight, some method of correcting the final weight for beginning weight had to be devised. One can immediately see a similiar situation developing when the effects of exercise types on quadricep strength and vertical jumping performance is investigated; the variability in quadricep strength and vertical jumping must be accounted for.

Should the ANCOVA treatment indicate any differences among the post adjusted means of the four groups, a *t* test for the analysis of difference between means was used. In order to assess the significance of mean gains within each exercise treatment, a paired *t* test was used.

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[7] Michael C. Carter, Appalachian State University Statistical Consultant, in personal communication, October, 1971.

[8] Winfrid Dixon and Frank Massey, *Introduction to Statistical Analysis* (New York: McGraw-Hill Book Company, 1969), p. 223.

CHAPTER IV

ANALYSIS AND PRESENTATION OF DATA

Introduction

The analysis of covariance technique was used to analyze the data. The covariance analysis indicated whether or not differences existed among the post means of the four groups after nine weeks of training. If the analysis of covariance indicated the presence of significant differences among the adjusted post means, a *t* test was utilized to determine which post means were significantly different from the other. Paired *t* tests were were used to indicate any significance of mean differences from T-1 to T-2 within each treatment group.

Test-Retest Reliability

Rank-order correlations were used to assess the reliability of the testing procedures used in this research. Two quadricep strength tests and vertical jumping tests were administered one week apart in order to determine rho coefficients prior to the actual administration of the tests. At the 0.05 level of confidence with the N equal to six, a coefficient of 0.829 was required for significance. The

coefficient for the cable tension test of quadricep strength was 0.863; for the vertical jump test the coefficient was 0.943.

Analysis of Quadricep Strength Data

Introduction. Based on the overall regression F ratio of 30.27 (significant at the 0.001 level of confidence), the covariable or pre-measurement provided the most significant concomitant information. It appeared that these pre-measurements reflected other variables such as height, weight, and age; however, the relationship of these variables to pre-strength was not investigated as such information was not germane to the study.

In the analysis, the response was post-quadricep strength and the covariable was the pre-training strength measurement. The response was indicated by Y_{ij} and the covariable was X_{ij} where i denoted the group and j denoted a subject in the ith group.

Table I presents a summary of the pertinent statistics. In four cases, a symbol followed the name of the statistic which will later be used in a discussion of the results of the analysis.

Between Regression Analysis. Initially the ANCOVA included four groups, but the F ratio of the between regression (F=2.88, significant at the 0.10 level of confidence) indicated that the four treatment regressions were not

TABLE I

SUMMARY OF STATISTICS FOR
QUADRICEP STRENGTH

STATISTIC	ISOTONIC	ISOMETRONIC	ISOMETRIC	CONTROL
Cell Size N_i	5	6	7	
Post Mean $\overline{Y}_i$	273.45	271.29	268.85	226.87
Post Adusted Mean $\overline{Y}_i$	284.84	270.19	261.37	226.87
Post Std. Deviation	44.91	31.47	62.63	62.87
Pre Mean $\overline{X}_i$	199.95	211.08	210.42	219.75
Pre Std. Deviation	4.12	29.55	55.35	33.38
Regression Coefficient	+2.57	-0.33	+1.09	+1.71
Overall Post Mean		262.38		
Overall Post Standard Deviation		49.88		
Overall Pre Mean		209.92		
Overall Pre Standard Deviation		35.89		

homogeneous; i.e., a single regression line could not be used to replace the individual regression lines. The individual regression lines for each group for quadricep strength are presented in Figure 6. Table II presents the between regression ANOVA for all four groups.

TABLE II

BETWEEN REGRESSION ANOVA FOR
ISOTONIC, ISOMETRIC, ISOMETRONIC, AND CONTROL GROUPS

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES	F
Overall Regression	1	23160.5	23160.5	
Between Regression	3	9639.8	3213.3	2.88*
Error	14	15608.5	114.9	
Total	18	48408.8		

*Significant at the 0.10 level of confidence.

With the heterogenieity present as indicated by a significant between regression F ratio, there was no common basis or criterion to use in adjusting post quadricep strength scores. Therefore, the four treatment groups (isotonic, isometric, isometronic, and control) could not be compared as originally designed. The heterogeneity expressed as a significant between regression F ratio indicates that the treatments affected the groups differently, both in the degree of effect and in the manner the groups were effected. To compare the four groups, they must react to the training

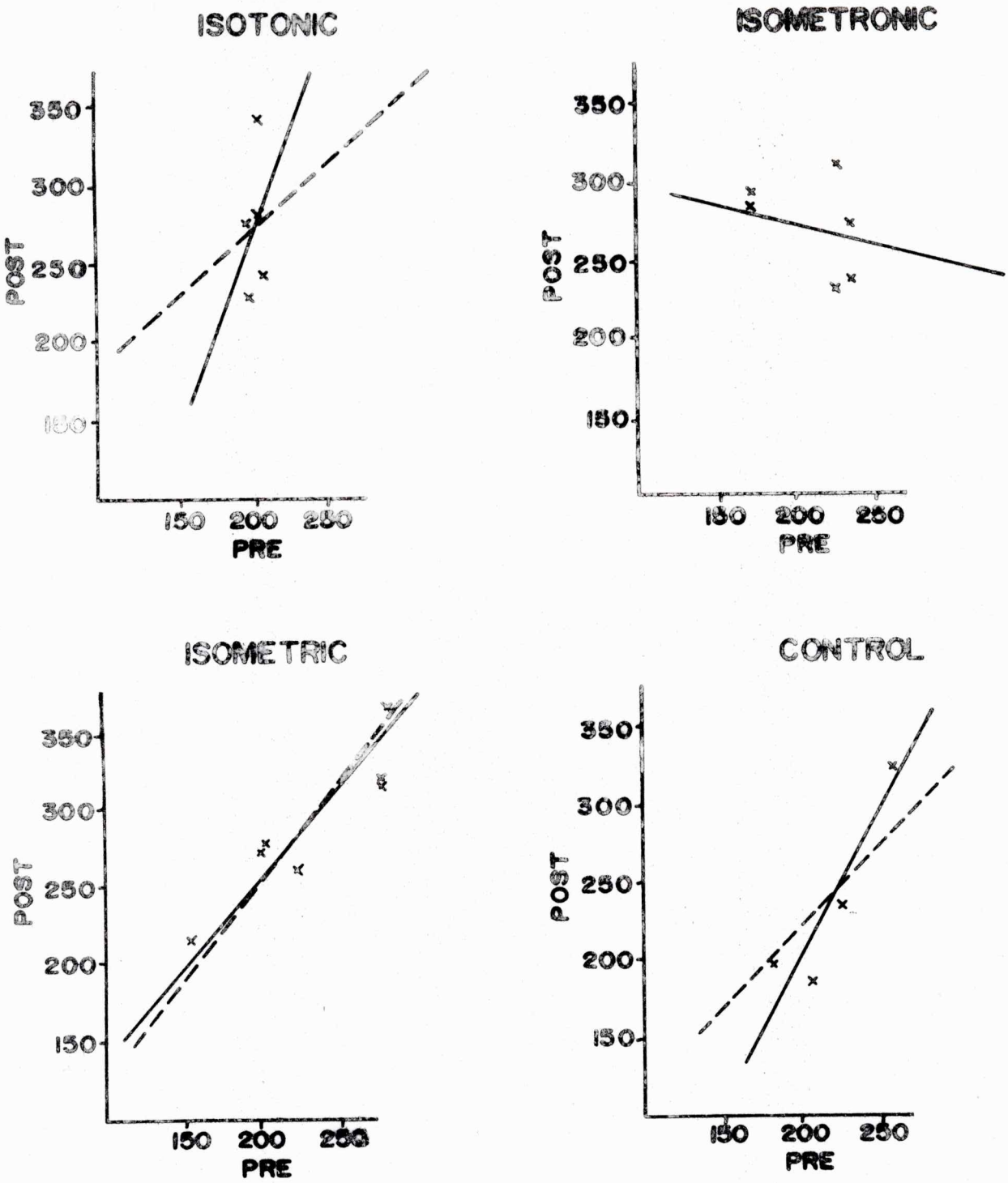

FIGURE 6

GROUP REGRESSION LINES (SOLID LINES) AND OVERALL REGRESSION LINE (SLASHED LINE) FOR QUADRICEP STRENGTH MEASUREMENTS

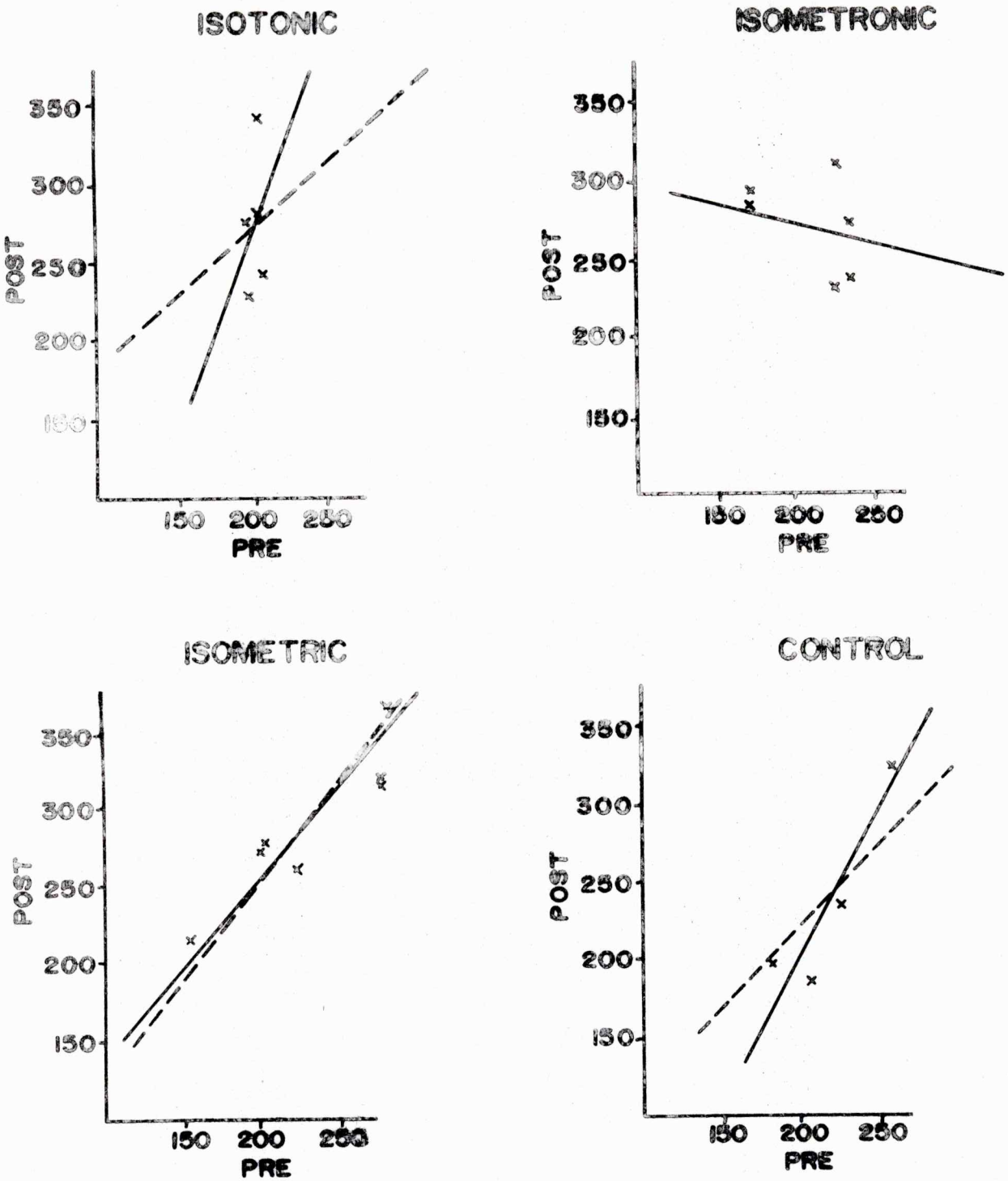

FIGURE 6

GROUP REGRESSION LINES (SOLID LINES) AND OVERALL REGRESSION LINE (SLASHED LINE) FOR QUADRICEP STRENGTH MEASUREMENTS

stimulus in a similiar manner; this would allow the degree of effect to be evaluated.

An examination of Table I and Figure 6 reveals where the group regressions are heterogeneous. The regression line for the isometronic group (-0.33) differed distinctly from the lines of the isometric, isotonic, and control groups (+2.57, +1.09, and +1.71, respectively). In the isometric, isotonic, and control groups it was observed that subjects with low pre-quadricep strength increased their capabilities with approximately the same proportion as those with high pre-quadricep strength; i.e., the treatments improved weak quadriceps as well as, but no better than, they improved strong quadriceps. This trend was apparently altered with the isometric-isotonic training. This exercise drastically improved the quadricep strength of those with initially low strength but only slightly improved those subjects starting with higher pre-training quadricep strength. Thus, the manner in which the treatments affected the subjects was different; therefore, the isometric-isotonic group could not be compared with the isometric, isotonic, and control groups. Since the isometric-isotonic group could not be compared with the other ghree groups, the isometric, isotonic, and control groups were again analyzed with the ANCOVA treatment.

The between regression F ratio for three groups (isometric, isotonic, and control) with two and ten degrees of freedom was 0.542. This F ratio was non-significant

which indicated homogeneity among the regression lines of the isometric, isotonic, and control groups.

Table III presents the between regression analysis of variance for isometric, isotonic, and the control group.

Overall Regression Analysis. With the between regression F ratio being non-significant, the ANOVA for overall regression was performed. The overall regression line

TABLE III

BETWEEN REGRESSION ANOVA FOR ISOMETRIC, ISOTONIC, AND CONTROL GROUPS

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES	F
Overall Regression	1	31124.1	31124.1	
Between Regression	2	1208.0	604.0	0.542
Error	10	11129.1	1112.9	
Total	13	43461.2		

had a coefficient of 1.19. The overall F ratio was highly significant (F=30.27, significant at the 0.001 level of confidence). This indicated that all subjects' responses could be adjusted to an overall regression line. Table IV presents the overall regression ANOVA for the isometric, isotonic and control groups.

TABLE IV

OVERALL REGRESSION ANOVA FOR
ISOMETRIC, ISOTONIC, AND CONTROL GROUPS

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES	F
Regression	1	31124.1	31124.1	30.27*
Error	12	12337.1	1028.1	
Total	13	43461.2		

*Significant at the 0.001 level of confidence.

Adjusted Responses. The post-training quadricep strength responses were adjusted for the effect of the pre-training quadricep strength scores, allowing the adjusted observations to respond in a similiar manner to the treatment. Table V presents the ANOVA on the adjusted observations. The F ratio for the adjusted observations (F=4.037) was significant at the 0.05 level of confidence; therefore, the differences between the groups on adjusted post-training quadricep strength scores was soley attributed to the treatments.

TABLE V

ANOVA FOR ADJUSTED OBSERVATIONS FOR
ISOMETRIC, ISOTONIC, AND CONTROL

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES	F
Treatment	2	8301.5	4150.5	4.037*
Error	12	12336.8	1028.1	
Total	14	20638.3		

*Significant at the 0.05 level of confidence.

Since the adjusted observations had a significant F ratio, the t test for difference between means was used to determine which post means (isometric, isotonic, and control) differed significantly from the others. The statistic used was:

$$t = \frac{\hat{\bar{Y}}_i - \hat{\bar{Y}}_j}{\sqrt{\text{M.S. Error}\left(\frac{1}{n_i} + \frac{1}{n_j} + \frac{(\bar{x}_i - \bar{x}_j)^2}{\sum\sum\left(x_{kl} - x_k{}^2\right)}\right)}}$$

The t analysis for differences between means revealed that the increase in quadricep strength resulting from isotonic exercise was significantly greater (0.05 level of confidence) from strength increases in the control group. The quadricep strength resulting from isometric exercise was non-significantly different (0.05 level of confidence) from strength increases resulting from isotonic exercise and the non-exercise control group. Table VI shows the comparison between the post adjusted means for quadricep strength.

TABLE VI

COMPARISON OF POST ADJUSTED MEANS
FOR QUADRICEP STRENGTH

GROUP		GROUP COMPARISON	t*
Isotonic	(I)	I-III	1.24
Isometric	(III)	III- IV	1.65
Control	(IV)	IV- I	2.64*

*t=2.18 required for significance at 0.05 level of confidence with 12 degrees of freedom.

Mean Gains in Quadricep Strength. Paired t tests were utilized to determine if mean differences between the covariables and responses of each group were significant. The t test used was:

$$t = \frac{M_d}{\sqrt{\frac{\sum x_d^2}{N\ (N-1)}}}$$

The t test for paired observations revealed that all training groups made significant gains in strength from T-1 to T-2; the control group did not make a significant change in quadricep strength from T-1 to T-2. The isotonic group (N=5) showed a mean gain of 78.43 pounds. The isometric group (N=7) had a mean gain of 73.50 pounds, and the isomettronic group (N=6) produced a mean gain of 60.21 pounds. The control group had a mean gain of 16.25 pounds. Figure 7 illustrates the mean increases in quadricep strength of each group. Table VII presents t values for quadricep strength changes.

TABLE VII

QUADRICEP STRENGTH t VALUES FOR MEAN GAINS

GROUP	N	d.f.	REQUIRED t VALUE	Calculated t VALUE
Isotonic	5	4	2.132	3.714
Isometronic	6	5	2.015	2.989
Isometric	7	6	1.943	2.509
Control	4	3	2.350	0.930

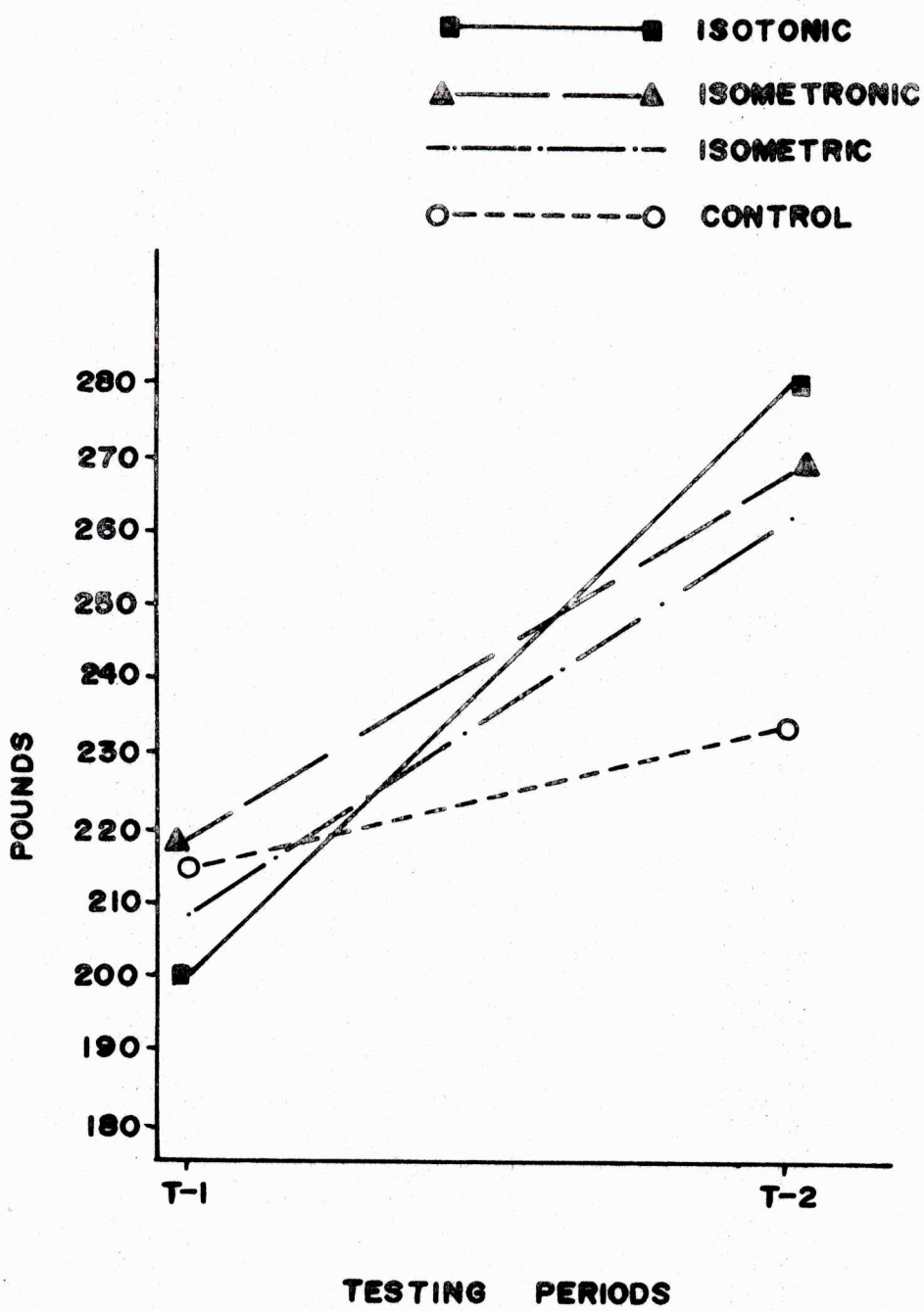

FIGURE 7

GROUP MEAN GAINS IN QUADRICEP STRENGTH

Discussion of Quadricep Strength Changes. It is informative to consider the consequences of not checking whether the regression lines were homogeneous and directly comparing the four groups adjusted for the covariable. Had the results of the ANOVA showing heterogeneity been ignored, the ANOVA on the adjusted means would show nothing; i.e., the F ratio for the adjusted observations of 1.68 would have been non-significant and the conclusion would be that there was no difference between the exercise types.

While all exercising groups made significant mean gains (0.05 level of confidence), the isometric-isotonic group could not be compared to the isometric, isotonic, and control groups due to violation of the homogeneity of regression. With the isometronic group removed and homogeneity of regression validated for the three remaining groups, a significant difference existed among the isotonic, isometric, and control groups. The significant difference was due to gains of the isotonic group over the control group. This agreed with the findings of Berger[1,2] and O'Shea[3].

The non-significant difference between the isometric group and the control group contradicted the findings of

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[1] Berger, "Comparison of the Effect of Various Weight Training Loads on Strength," loc. cit.

[2] Berger, "Comparative Effects of Three Weight Lifting Programs," loc. cit.

[3] O'Shea, loc. cit.

Hettinger and Muller[4] and Muller[5]. The non-significant differences between isotonic and isometric training agreed with the findings of Darcus and Salter[6] in which the greater percentage of improvement was achieved by dynamic training over static training. Their explanation for the lower scores of the isometrically trained group on an isometric test, later verified by Pierson and Rasch[7], was that there was no criterion of improvement in isometric training and that the possibility of resulting boredom may consciously or unconsciously cause a reduced effort by the subject.

It should be noted that the isometronic exercise (Exer-Genie) affected the members of that group in different ways. Those with low initial quadricep strength made large improvements, while those with a high initial quadricep strength tended to make only slight improvements. This neither agreed with nor contradicted other studies[8,9,10] employing the Exer-Genie but offered a new point worthy of investigation.

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[4] Hettinger and Muller, loc. cit.

[5] Muller, loc. cit.

[6] Darcus and Salter, loc. cit.

[7] W. Pierson and P. Rasch, "The Effect of Knowledge of Results on Isometric Strength Scores," Research Quarterly, 25:314, October, 1964.

[8] Long, loc. cit.

[9] Waddle, loc. cit.

[10] Halpren, loc. cit.

Analysis of Vertical Jump Data

Introduction. The analysis of covariance technique was used to make comparisons among the groups at T-2 using the vertical jump scores at T-1 as the covariable in order to determine the effect of isotonic, isometric, and isometronic exercises on vertical jumping performance.

Between Regression Analysis. Avoiding the situation found in the ANCOVA on quadricep strength, no complications arose in this ANCOVA. The F ratio (F=1.64) for the between regression ANOVA of four groups was non-significant indicating that the four groups' regressions were homogeneous; i.e., they could be represented by a single regression line. See Table VIII for between regression ANOVA.

TABLE VIII

BETWEEN REGRESSION ANOVA FOR ISOTONIC ISOMETRIC, ISOMETRONIC AND CONTROL GROUPS

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES	F
Overall Regression	1	55.094	55.094	
Between Regression	3	11.323	3.774	1.644
Error	14	32.131	2.295	
Total	18	98.548		

Overall Regression Analysis. With a nonsignificant between regression F ratio, The ANOVA for overall regression was performed. The overall regression coefficient is 0.792

and the overall regression line is highly significant (F=21.55, 0.01 level of confidence). The overall regression analysis revealed that pre-training vertical jump ability contributed to post-training vertical jump performance and that all scores should be adjusted for the effect of the co-variable. Table IX presents the overall regression ANOVA.

TABLE IX

OVERALL REGRESSION ANOVA FOR ISOTONIC ISOMETRIC, ISOMETRONIC, AND CONTROL GROUPS

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES	F
Overall Regression	1	55.094	55.094	21.533*
Error	17	43.454	2.556	
Total	18	98.548		

*Significant at the 0.01 level of confidence.

Table X presents a summery of pertinent statistics including individual and overall regression coefficients. Figure 8 represents a graphical illustration of the regression lines of the four groups.

Adjusted Responses. Post-training vertical jump scores were adjusted for pre-training vertical jump scores. The ANOVA on the adjusted responses yielded a non-significant F ratio (F=0.813). The non-significant F ratio indicated that there was no differences among the post means

TABLE X

SUMMARY OF STATISTICS FOR
VERTICAL JUMP

STATISTIC	ISOTONIC	ISOMETRONIC	ISOMETRIC	CONTROL
Cell Size	5	6	7	4
Post Mean	23.00	21.17	20.57	20.00
Post Adjusted Mean	21.42	21.89	20.79	20.49
Post Std. Deviation	2.23	2.64	2.09	2.41
Pre Mean	22.50	19.58	20.21	19.88
Pre Std. Deviation	1.91	3.04	1.68	1.84
Regression Coefficient	+1.138	+0.453	+1.145	+1.251
Overall Post Mean		21.18		
Overall Post Standard Deviation		2.24		
Overall Pre Mean		20.50		
Overall Pre Standard Deviation		2.34		

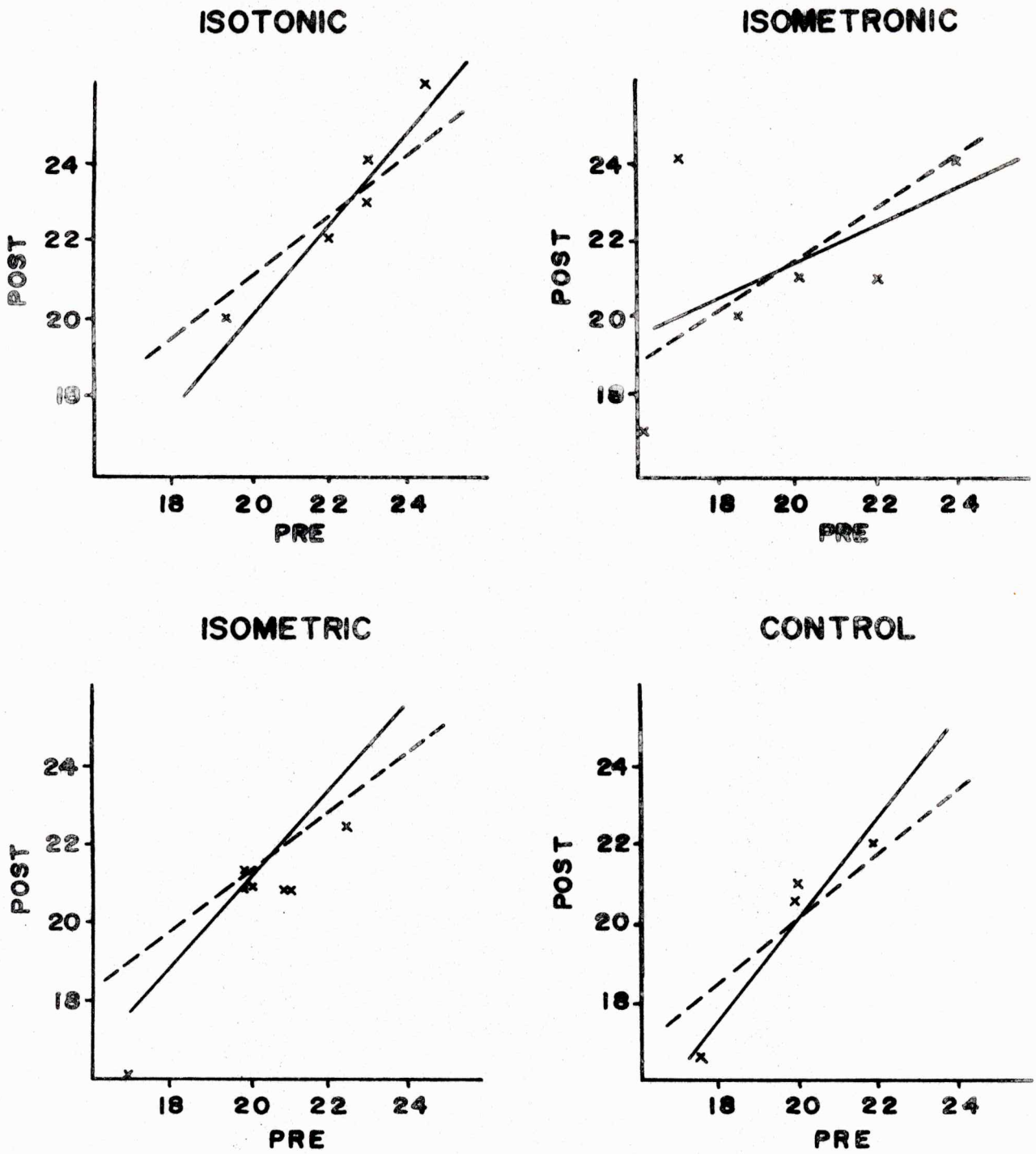

FIGURE 8

GROUP REGRESSION LINES (SOLID LINES) AND OVERALL REGRESSION LINES (SLASHED LINES) FOR VERTICAL JUMP MEASUREMENTS

of the four groups. Table XI presents the ANOVA for adjusted observations.

TABLE XI

ANOVA FOR ADJUSTED OBSERVATIONS FOR ISOTONIC ISOMETRIC, ISOMETRONIC, AND CONTROL GROUPS

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES	F
Treatment	3	6.239	2.079	0.812
Error	17	43.447	2.555	
Total	20	49.687		

Mean Gains in Vertical Jump Performance. A *t* test for paired observations was used to determine mean differences between the pre-training and post-training responses of each of the four groups.

The *t* analysis revealed no significant differences between T-1 and T-2 means of vertical jump for any of the four groups. The isotonic group (N=5) showed a mean gain of 1.1- inches. The isometric (N=7) group registered a mean gain of 0.36 inches. The isometronic group (N=6) had a mean gain of 1.58 inches. The control group (N=4) had a mean gain of 0.12 inch. Table XII presents the *t* values for each group. Figure 9 illustrates the mean gains of each group from T-1 to T-2.

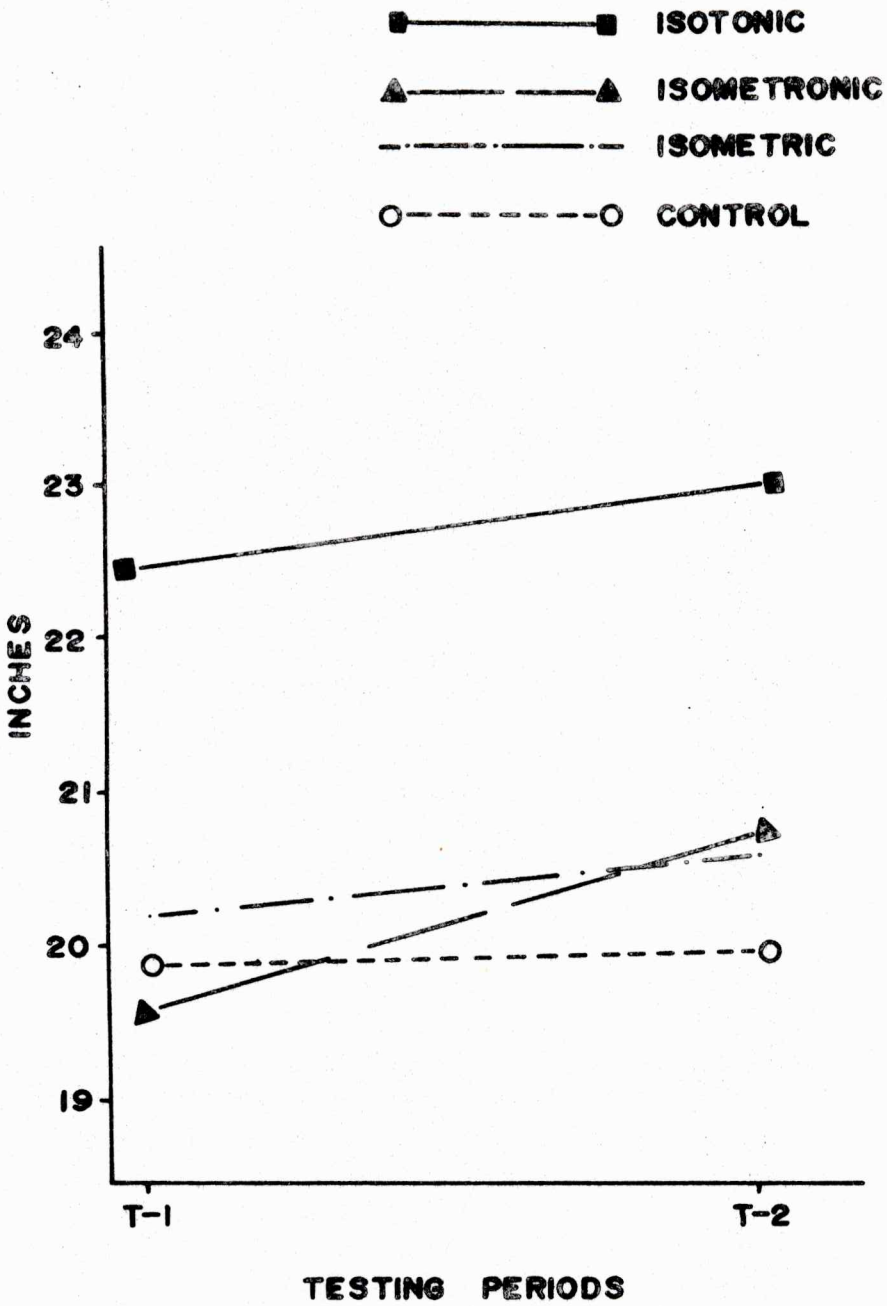

FIGURE 9

GROUP MEAN GAINS IN VERTICAL JUMP PERFORMANCE

TABLE XII

VERTICAL JUMP t
VALUES FOR MEAN GAINS

GROUP	N	d.f	REQUIRED t VALUE	CALCULATED t VALUE
Isotonic	5	4	2.78	2.06
Isometronic	6	5	2.57	1.11
Isometric	7	6	2.45	1.33
Control	4	3	3.18	0.29

Discussion of Vertical Jump Changes. The non-significant changes in vertical jump performance following different methods of quadricep strength training coincides with the findings of Capen[11], Ball, et al.[12], and Lindeburg, Edwards and Heath[13] and Berger[14]. However, the case of isotonic training not producing significant increases in vertical jump performance sharpely contradicts the work of Chui[15], Aldrich[16], Hopkins[17], and Anderson[18]. Training for the

[11] Capen, loc. cit.
[12] Ball, et al., loc. cit.
[13] Lindeburg, loc. cit.
[14] Berger, "Effects of Dynamic and Static Training on Vertical Jumping Ability," loc. cit.
[15] Chui, loc. cit.
[16] Aldrich, loc. cit.
[17] Hopkins, loc. cit.
[18] Anderson, loc. cit.

experimental groups was with the knee extension rather than the squat-type of movement used in other research. With the similiarity of the squat movement and the vertical jump movement, neuromotor patterns could be similiar. This similarity explains the significant vertical jump improvements which followed the squat type training. The non-significant vertical jump performance increase which followed knee extension training from a seated position could be due to neuromotor specificity.

Increases in isometric strength as measured by a cable tensiometer were not accompanied by corresponding changes in vertical jumping performance. This may add support to the contention that dynamic performances require different neuromuscular patterns than maximum isometric exertion. Larson[19] indicated that strength was more of the function of the ability of a muscle to register its strength on instruments although not necessarily being able to lift the body weight or propel it upward as in the vertical jump. Henry and Whitely[20] reached similiar conclusions in their research stating that different control patterns are involved when the muscle is moving a limb than when the muscle is exerting simple static tension. It might also be noted that the greatest raw mean change in vertical jump ability was in the isometronic group. Again, this may have

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[19] Larson, loc. cit.

[20] Henry and Whitely, loc. cit.

been due to the tendency for the Exer-Genie to affect those with lower initial ability to a greater degree than it did with those of greater initial scores. (See Appendix B for raw scores). It should be noted that there was a trend in favor of the isotonic group toward increased performance in vertical jumping.

CHAPTER V

SUMMARY CONCLUSIONS AND RECOMMENDATION

Summary

Introduction. Today's researchers, coaches, and trainers are constantly searching for the optimum method for the development of muscular strength and power within a limited period of time. Isometric, isotonic, and isometronic (Exer-Genie) systems of strength development have been utilized in various sports activities as a part of their training regimens. Research concerning isometric and isotonic training has been, at best, controversial. Research dealing with isometric-isotonic development of muscular strength and vertical jump performance has been limited. Due to the research being controversial and because little research has been published investigating these three forms of resistance exercise (isometric, isotonic, and isometronic) concurrently, a comparison of the three types of exercise and their effects on quadricep strength and vertical jumping performance was deemed warranted. More specificly, this research sought to:

1. investigate any significant differences between groups that might occur in quadricep strength and vertical

jumping performance after nine weeks of training with isometric, isotonic, and isometronic exercise programs.

2. determine the effect of isometric, isotonic, and isometronic training on quadricep strength and vertical jumping performance from T-1 to T-2.

Twenty-four male students enrolled in Appalachian State University during the spring quarter of 1971 were used as subjects in this research. Subjects ranged in age from 18.58 years to 25.50 years with the mean age being 19.77 years. The subjects were randomly assigned to one of three experimental groups or to a control group.

Group I trained isotonically performing three sets of quadricep extension with each leg using the six repetition maximum. Group II trained utilizing the Exer-Genie. The subjects performed three repetitions according to the following: the exercise was begun with an isometric contraction at 90 degrees of knee extension concluded by an isotonic movement against progressive resistance through the full range of extension. Group III performed a maximal isometric knee extension of six seconds duration at three positions with each leg: 90 degrees, 110 degrees, and 130 degrees of knee extension. Group IV participated as a control group and participated only in the initial and the final testing periods. All subjects trained twice weekly for nine weeks on Mondays and Wednesdays; Fridays were used as a make-up day. Testing occurred before training (T-1) and at the conclusion of nine weeks of training (T-2).

Literature. Early research about the development of muscular strength indicated that strength could be developed as a result of short static contractions. The literature reviewed seemed to support the hypothesis that strength can be developed isometrically provided the threshold is at least two-thirds of the muscle's maximal contractile capability. Research indicated that both the single and the repetitive method of isometric training have produced significant gains in muscular strength.

Much of the research reviewed concerning the isotonic development of strength has investigated the questions of determining the optimum number of repetitions and sets of repetitions in order to derive maximal gains in muscular strength. Various numbers of repititions and sets of repetitions were demonstrated to have produced significant increases in muscular strength. Submaximal isotonic efforts were shown to be equally as effective as maximal isotonic work in the development of strength. Comparisons of isometric and isotonic techniques of muscular strength development have concluded that no significant differences exist; both systems of training have resulted in significant increases in strength.

Little research was reviewed in which the Exer-Genie was investigated; however, several reports were reviewed in which the isometric-isotonic principle was used in experimental designs. The Exer-Genie and the isometric-isotonic method of training was demonstrated to have a significant

value in the development of strength. The research cited, presented evidence that the Exer-Genie was of value in the development of muscular strength.

Various isotonic training techniques were found to be of significant value in the development of vertical jump performance. The literature reviewed revealed that isometric training will not result in significant improvement in vertical jumping performance.

The relationship of isometric strength and performance in such activities as the vertical jump was discussed. It was concluded that strength exerted statically involved different neuromotor patterns than those patterns involved in vertical jumping.

Methodology. Quadricep strength was measured at 115 degrees of knee extension. The subjects were given three trials with each leg; the maximum reading exerted by each leg was recorded. A vertical jump test was administered in which the subject took no preliminary hops or movements. The difference between standing arms reach and the highest point marked during the jump was recorded as the vertical jump distance.

The technique for analyzing the data was the analysis of covariance (ANCOVA). ANCOVA is a technique used when experimental units within groups are assumed to be heterogeneous and a variable thought to explain the heterogeniety is measured in conjunction with the response. The analysis

of covariance indicated whether or not post adjusted means were significantly different from one another. If the ANCOVA indicated whether significant differences were present, a t test was utilized to determine which post adjusted means were different from the other. A t test for paired observations was utilized to determine the significance (or non-significance) of improvement from T-1 to T-2.

Data Analysis. Initially, the analysis for quadricep strength measurements included four groups, but due to the non-homogeniety as indicated by a significant between regression F ratio, the isometronic group was removed from the analysis which resulted in homogeniety among the three remaining groups (isometric, isotonic, and control). The heterogeniety resulting because of the isometronic group was accounted for by subjects with low initial quadricep measurements making extremely large gains in strength and subjects with high initial quadricep measurements making only slight improvements in quadricep strength. With a significant overall regression present, an ANOVA was performed on the adjusted post means of the isometric, isotonic, and control groups indicated significant differences existed. The t analysis for differences between means indicated that strength increases resulting from isotonic exercise was non-significant from increases resulting from isometric exercise and significantly different from gains that occurred in the non-exercise control group. The paired

t test for mean differences indicated that all experimental groups had significant increase in quadricep strength.

In the analysis of the vertical jump data, all groups were homogeneous with the between regression F ratio being non-significant. The post adjusted means were treated with an ANOVA yielding a non-significant F ratio, therefore, indicating that no significant differences existed among the four groups at the final testing. A t analysis for mean differences for each group revealed that none of the groups made significant increases in vertical jumping performance from T-1 to T-2.

Increases in isometric quadricep strength were not accompanied by corresponding changes in vertical jump performance. This phenomenon was explained by specificity of training; i.e., different neuromotor patterns are involved when exerting simple static tension than when vertical jumping.

Conclusions

Within the scope of this research and the limitations established by the sample population and the statistical analysis, the following conclusions were made:

1. Isotonic exercise was significantly superior to isometric exercise and control activity in the development of static strength of the quadriceps.

2. Progressive resistance exercise resulted in a significant increases in static strength.

3. Isometric-isotonic (Exer-Genie) training resulted in a significant increase in static strength of the quadriceps.

4. Isometric exercise resulted in a significant increase in static strength of the quadriceps.

5. Control group activity resulted in no significant increases in static strength of the quadriceps.

6. There were no significant differences among post means of the isotonic, isometric, isometronic, and control groups in the development of vertical jumping performance.

7. Isotonic, isometric, and isometronic training resulted in no significant increases in vertical jumping performance.

Recommendations

As a result of this investigation into the effects of isometric, isotonic, and isometronic training programs on the strength of the quadriceps and vertical jumping performance, the recommendations for further investigations are as follows:

1. The incorporation of a larger sample population in an experimental design similiar to that found in this research could serve to futher substantiate findings of this research or could refute the findings therein.

2. An investigation of the effects of isometric, isotonic, and combined isometric-isotonic programs of training on quadricep strength and vertical jumping perform-

ance, training and testing the subjects in a squat type movement.

3. An investigation into the individual component functions of the Exer-Genie could be done to reveal the contributions of the isometric phase or the isotonic phase, and the combined isometric-isotonic movement.

4. A study could be done to investigate the relationship of maximum isometric strength to maximum isotonic strength.

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APPENDICES

APPENDIX A

TABLE I

SUBJECT INFORMATION

GROUP	SUBJECT	AGE (yrs.)	HEIGHT (ins.)	WEIGHT (lbs.)
Isotonic	WR	21.50	71.00	179.75
	DW	20.33	68.00	164.50
	MD	19.83	68.00	134.00
	PJ	19.25	71.00	173.00
	RH	19.33	73.25	187.50
Isometronic	AC	22.00	70.25	156.75
	NG	18.83	70.00	151.25
	MW	20.18	67.00	166.25
	GM	19.42	68.75	162.75
	WB	23.25	74.75	236.25
	TM	23.25	67.00	207.50
Isometric	JW	22.08	67.00	158.00
	DR	19.16	69.25	165.75
	CB	18.66	69.00	148.75
	DE	19.08	72.75	140.75
	RC	18.75	72.00	135.50
	BB	20.25	73.00	189.50
	BB	18.51	68.25	135.00
Control	KW	19.83	73.50	229.00
	NE	19.50	73.00	158.00
	JM	22.75	69.50	148.00
	JF	25.50	65.00	185.00

APPENDIX C

TRAINING AND TESTING SCHEDULE

March	10	First class meeting; explain procedures.
	15	Testing: quadricep strength, take anthropometric measurements; familiarize with vertical jump.
	17	Testing: vertical jump; familiarize subjects with their work routines.
	22	Train
	24	Train
	29	Train
	31	Train
April	5	Train
	7	Train
	12	Train
	14	Train
	19	Train
	21	Train
	26	Train
	28	Train
May	3	Train
	5	Train
	10	Train
	12	Train
	17	Train
	19	Train

APPENDIX C (continued)

May	20	Testing
	21	Testing
	22	Testing

There was a total of nine weeks of training; twice per week, Mondays and Wednesdays.