8-1979

A Comparison of Isotonic Versus Isokinetic Exercise in the Development of Strength and Concomitant Enhancement of Body Proportions for College Females

Diane Lloyd Gillo
Western Michigan University

A COMPARISON OF ISOTONIC VERSUS ISOKINETIC EXERCISE IN THE DEVELOPMENT OF STRENGTH AND CONCOMITANT ENHANCEMENT OF BODY PROPORTIONS FOR COLLEGE FEMALES

by

Diane Lloyd Gillo

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Master of Arts

Western Michigan University
Kalamazoo, Michigan
August 1979

A COMPARISON OF ISOTONIC VERSUS ISOKINETIC EXERCISE IN THE DEVELOPMENT OF STRENGTH AND CONCOMITANT ENHANCEMENT OF BODY PROPORTIONS FOR COLLEGE FEMALES

Diane Lloyd Gillo, M.A.

Western Michigan University, 1979

This study compared Isotonic to Isokinetic exercise in an eight-week resistance training program for college females. Strength development and anthropometric measurements were evaluated by the correlated _t_ test of initial and final scores. The independent _t_ test compared mean improvement scores between the Isotonic group (N=14) and the Isokinetic group (N=15). All strength items showed significant improvement within each group; however, neither program proved superior for general strength gain. The only significant difference between groups favored the Isotonic group in leg extension. A trend was observed in enhancement of body proportions, measured anthropometrically. An increase in total body weight combined with a decrease in relative body fat indicated an increase in muscle hypertrophy, as evidenced by the significantly increased girths of the upper arms. The decrease in lower limb girths may be due to hypertrophy of muscle fibers with a concomitant decrease in surrounding fat tissue.

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my thesis adviser, Dr. Roger Zabik. His advice and guidance during the study were invaluable. The assistance of the other members of my advisory committee, George Dales and Dr. Harold Ray, is gratefully acknowledged.

My appreciation is extended to Jeff Willson for his assistance during the testing and treatment of the Isokinetic group, and to Lee Kermode and Maryann Zickler of the Athletic Training Department for their cooperation in the use of facilities and equipment.

The staff of the Health, Physical Education and Recreation office and Intramural office of Western Michigan University deserve recognition for offering every courtesy in helping me to attain my goal.

I would like to offer my heartfelt thanks to the girls who volunteered for the study, and were dedicated to its completion.

Lastly, but very important, my thanks to my husband, Ray, for his love and understanding during the many months of the study.

Diane Lloyd Gillo

1313535

GILLO, DIANE ELAINE LLOYD
A COMPARISON OF ISOTONIC VERSUS ISOKINETIC EXERCISE IN THE DEVELOPMENT OF STRENGTH AND CONCOMITANT ENHANCEMENT OF BODY PROPORTIONS FOR COLLEGE FEMALES.

WESTERN MICHIGAN UNIVERSITY, M.A., 1979

University Microfilms International 300 N. ZEEB ROAD, ANN ARBOR, MI 48106

PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark ✓.

1. Glossy photographs ✓
2. Colored illustrations ____
3. Photographs with dark background ____
4. Illustrations are poor copy ____
5. Print shows through as there is text on both sides of page ____
6. Indistinct, broken or small print on several pages ____ throughout ____
7. Tightly bound copy with print lost in spine ____
8. Computer printout pages with indistinct print ____
9. Page(s) ____ lacking when material received, and not available from school or author ____
10. Page(s) ____ seem to be missing in numbering only as text follows ____
11. Poor carbon copy ____
12. Not original copy, several pages with blurred type ____
13. Appendix pages are poor copy ____
14. Original copy with light type ____
15. Curling and wrinkled pages ____
16. Other ____

TABLE OF CONTENTS

LIST OF TABLES

TABLE		PAGE

TABLE		PAGE

TABLE | PAGE

TABLE PAGE

TABLE | PAGE

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The affirmation of the need for physical fitness for all ages has generated an interest in specifying the effects of physical training on females. Drinkwater (15:125) accentuates the need to evaluate female response to stress. Sexual differences may affect both physical performance in an activity and the standards of safety which have been determined primarily for males.

According to Ulrich, (57:11) in comparison with the average adult male, the average adult female is shorter and weighs less. Her weight consists of a greater percentage of fat tissue and less muscle tissue. These variations may result in performance differences, with females under-performing males in events in which height or even the height-to-weight ratio is important. In the case of activities affected by buoyancy in water, female performance more closely approximates that of the male. Ulrich (57) further emphasizes the longer period of development of the male, which benefits his greater proportional growth. This longer growth period may provide relative structural advantages in the development of the upper body. Body variations may account for the inherent difference in the absolute strength of males versus females, but the percentage of strength difference varies from one muscle group to another. The continual use of a muscle contributes a stimulus for strength development, as evidenced by the greater degree of strength in the limbs used for locomotion.

In females, there exists a disproportion between the relative strength of the legs versus the upper torso. This results from the imposed limitations of the social milieu concerning activities which utilize the muscles of the upper body. Thomas (54:370) states that the taboo regarding the use of females in research studies has affected the present state of female athletics. The future of females in athletics is directly proportional to the interest or lack of it by women themselves.

It is beyond the scope of this study to attempt to alter the attitude of society regarding training and athletic participation by females. In accord with the national impetus toward maintaining a fitness level consistent with optimal health, further research should be continued in this area.

Statement of the Problem

Much data have been gathered on male subjects in the field of resistance training; however, the scope of research involving females has been limited. It has been substantiated that resistance training for males significantly increases strength levels and may lead to extreme hypertrophy of musculature. For this reason, this study was designed to compare the effects of two programs of resistance training on female subjects. The study was primarily concerned with strength development in the upper arms and in the legs of the subjects. Anthropometric measurements were used to assess changes in body proportions, especially changes in limb girths due to muscle hypertrophy.

Purpose of the Study

The purpose of the study was: (1) to determine whether isotonic or isokinetic exercise used in a program of resistance training was superior for strength development in female subjects, and (2) to determine if resistance training affected anthropometric measurements of body proportions, particularly any change in limb girths.

Definition of Terms

Absolute strength. Measurement of the maximal amount of force that a muscle is capable of exerting. (23:208)

Anthropometry. Measurement of the size and dimensions of the human body. (30:250)

Concentric contraction. Contraction in which the muscle shortens while overcoming the resistance. (1:19)

Eccentric contraction. Negative resistance contraction in which the muscle lengthens while contracting. (1:19)

Foot pounds. Unit of work measured by a dynamometer, which numerically equals a constant force of one pound moved through a distance of one foot. (31:127)

Hypertrophy. The increase in cross sectional area of individual muscle fibers with a decrease in surrounding fat tissue. (50:104)

Isokinetic contraction. Contraction in which the tension developed by a shortening muscle is maximal over the full range of motion of the joint. (53:280)

Isotonic contraction. Contraction in which the tension developed by a shortening muscle varies through the range of motion, while the load remains constant. (20:115)

Muscular endurance. The ability of a muscle to perform repetitions against a relatively light load for an extended period. (11:4; 20:114)

Muscular strength. The ability of a muscle to develop maximal tension against heavy resistance. (11:4)

Overload. Progressive increase of intensity as the training program improves individual capacity. (47:7)

Power. The rate of doing work, or work performed per unit of time. (33:737)

Relative strength. Measurement of strength expressed in terms relative to either total body weight or lean body mass. (35:110)

Repetition. One execution of an exercise movement. (31:142)

Repetition maximum (RM). Number of times that a maximal load can be lifted through the normal range of motion before fatiguing. (47:7)

Set. Number of consecutive repetitions of a specific exercise movement before a relief interval. (31:142)

Torque. The product of a force times the perpendicular distance from its axis of rotation. (60:147; 34:254)

Work. Force overcoming resistance and acting through a distance or range of motion; work = force X distance. (51:4)

Delimitations

This study was delimited to female college students: (1) who were attending Western Michigan University during the Winter semester of 1979; (2) who were between the ages of eighteen and twenty-five years of age; (3) who had no physical deficiencies that might have affected their participation in the study; and (4) who volunteered for the study.

Limitations

This study was limited by the following factors: (1) the current state of training was not considered during selection of the subjects; (2) there was no attempt to determine subject trainability; (3) there was no attempt to control outside participation in physical activities;

however, initiation of any training program, such as jogging, was discouraged during the eight-week period; (4) subject motivation could not be completely controlled, which may have influenced maximal performance; and (5) a one-week spring vacation intervened between the fifth and sixth week of the eight-week study. Subjects were asked not to engage in any resistance training programs outside of the study during that time.

Justification

Strength training is an integral part of the training program of most male athletes, but many female athletes have avoided resistance training because of the fear of masculinization (i.e. extreme muscle hypertrophy). The responsibility rests with researchers to determine whether these fears are substantiated. This study may inspire interest in resistance training for females as a means of increasing strength. The improvement of anthropometric dimensions, as a result of muscle toning through training, may prove influential in encouraging females to engage in resistance training.

CHAPTER II

REVIEW OF LITERATURE

This chapter reviews past studies related to resistance training in general, resistance training in females, anthropometry, isotonic training programs, and isokinetic training programs.

Resistance Training in General

Steinhaus (50:103) defined the changes resulting from exercise as "adaptations which facilitate performance of more exercise." He identified the physiological effects of muscular exertion resulting in increases in muscle size, strength and endurance. The enlargement of muscle, due to resistance training programs, was attributed to an increase in muscle fiber diameter, called hypertrophy. Steinhaus (50:105) recognized that hypertrophy was a function of the amount of work performed for any given unit of time. Darden (13:87) identified the amount of hypertrophy as dependent on muscle length, with the longer muscle having the capacity to gain more in cross-sectional area.

Jackson and Frankiewicz (23:206) identified humans as "movement oriented." Movement of any mass required exertion of a minimal amount of force. Muscles, the prime movers and prime stoppers of the body, were required to be in optimal condition. Contrary to popular opinion, the speed of contraction was not affected by resistance training. Strength in muscles improved functional ability. Clarke and Henry (9:315) cited the low correlation between static strength and speed of movement. But, in their study of fifty-two college males, they found that the speed of movement for any activity was increased by strengthening the muscles causing that movement. Steinhaus (50:107) reported the improved coordination of nervous impulses correlating muscular function to performance. Shambes (47:15) stated that resistance training stretched the muscle beyond its normal resting length, enabling a greater development of tension and thus contractile force. Resistance training developed dynamic strength, or the force applied through the full range of motion. The full completion of all movements ensured the development of the entire length of the muscle.

Jones (25) determined that human performance was based on body proportions, neurological efficiency, cardiovascular ability, skill, and muscular strength. Strength was the only productive factor, the other factors enabled the muscles to perform work. Ryan (46:41), Clarke (11:4), and Hislop and Perrine (20:114) defined strength as the ability to produce tension in a muscle by contraction. McCloy (29:9) stated that strength was related to muscular endurance, or work output extended over a period of time. Resistance training was used to develop either strength or endurance. DeLorme's axiom (46:41; 8:74) stated that maximum strength was obtained by working against maximal resistance. Maximum endurance was achieved by working a maximal number of times against a relatively low resistance. The physiological basis for the development of strength and endurance was in the overload principle, originated by Lange in 1919 (31:140) and first demonstrated experimentally by Petow and Siebert in 1925. (18:V) The overload theory was demonstrated by Hellebrandt and Houtz (16:380) in their study of seventeen normal young adults. They found evidence which supported the following conclusions:

1) Strength and endurance increased with repetitive exercise performed against heavy resistance.
2) The slope of the training curve varied with the magnitude of stress imposed, practice frequency and duration of the overload.
3) The mere repetition of contractions with no imposed stress did little to affect muscle capacity.

Therefore, as a muscle became conditioned to a resistance, the normal workload was increased. The term Progressive Resistance Exercise or PRE was developed to describe maintenance of overload during a program of resistance training. (31:141)

Resistance Training for Females

The need to evaluate the physiological effects of training on females increased in proportion to the number of female participants. Thomas (54:348) listed data concerning competition by female athletes in the Olympic Games. The year 1900 was the first for female entrants, with a total of six athletes competing. The Games of 1932 recorded 715 female athletes, or slightly over four percent of the total number of athletes; 1964 revealed 722 females at thirteen percent of the competition; and 1968 recorded approximately fourteen percent participation by female athletes.

Drinkwater (15:136) stated that the only long term data concerning female athletes were collected by Astrand. He followed thirty female swimmers for several years and published his report in 1963, with a follow-up account in 1971.

Hunsicker and Greey (22:110) reported that the strength of females increased rapidly from age nine to nineteen, with a leveling off until age thirty, when it declined. Wilmore (61:229) demonstrated that the strength of young non-athletic females was improved by up to thirty percent with a ten-week training program; in fact, some of the subjects doubled their strength in selected areas. He compared his subjects to a group of non-athletic males on an identical program. The females showed greater gains in strength, although their initial values were lower than the males. Hettinger (18:9) stated that general muscle strength of females was approximately two-thirds that of males. Muscle groups of the hip flexors and extensors averaged eighty percent of males and those of the forearm much less at fifty-five percent. Wilmore (61:229) maintained that strength in relation to the size of the muscle, or the strength potential, was similar in both sexes. Although the potential existed due to the comparable quality of muscle tissue, the muscles of the female were less responsive to training. Hettinger (18:44) recognized the direct relationship between muscle trainability and the presence of the sex hormone, testosterone. He noted that the administration of testosterone increased muscle weight but did not necessarily cause hypertrophy. An increase in the cross-sectional area of muscle fibers, approximating a proportional increase in strength, was adversely affected by atrophy caused by fat in the muscle.

Mathews and Fox (31:139) predicted the increase in lean body mass with a program of resistance training. They attributed a lack of significant girth increases to hypertrophy of individual muscle fibers with a concomitant decrease in fat surrounding the fibers. Mayhew and Gross (32:433) conducted a study of twenty-seven college females on a high resistance training program three days per week for nine weeks. Seventeen subjects trained with ten isotonic exercises in a two set, ten RM program. Strength testing for the leg press, bench press, arm curl and grip strength yielded significant improvements. They found that resistance training enhanced feminine body composition without masculinizing effects and without any marked change in total body weight. The authors concluded that high resistance training did not produce "bulky sinews" due to the low level of testosterone in their female subjects. They also concluded that previous investigators avoided exercising major muscle groups and had therefore noted no significant change in body proportions.

Sylvester (52:8) studied college females training with two programs of exercise. An isometric program and a program of stretching showed a reduction in upper arm girths. Sylvester concluded that before hypertrophy occurred, the muscle developed a minimal amount of tonus. Due to the limited use of upper body muscles by females in our society, any resistance training program probably produced muscle tone without an increase in limb girths.

Anthropometry

Attempts were made by various investigators to correlate anthropometric measurements with strength. (9:316; 35:112) Rasch and Pierson (43:211) stated that there was no direct way to determine the absolute force of muscle, because it was transmitted to the bones via the contraction of muscle fibers. Applied strength depended on a variety of physiological factors: muscular size, fiber arrangement, body weight, state of training, leverage ability, muscle fatiguability and recoverability. Rasch and Pierson trained adult males from the California College of Medicine for six weeks and compared their strength measures to a group of untrained males. The untrained displayed a correlation of forty-five percent between body weight and arm strength. The trained showed eighty-five percent correlation of measurements. Lamphiear and Montoye (26:148) doubted the validity of such a correlation, due to the negative correlation of strength and obesity in both sexes. Laubach and McConville (27:391) in their study of adult males, found no significant advantage in calculating lean body mass for correlation with strength measures.

Malina (30:265) found forearm circumference to be an indirect estimate of grip strength, but stressed that the muscles of grip comprise most of the forearm. Rasch and Pierson, (43:213) in the study mentioned above, found the correlation between arm strength and upper arm girth to be low, actually near zero. Roberts, et al (44:338) substantiated the low correlation between the girth of the upper limbs and strength in both males and females. But, they added that anthropometric measures were useful when considering the strength of specific muscular action. They correlated measures of upper and lower arm girths with the prediction of flexion and extension strength of the elbow.

Anthropometric measurements were of limited use in correlating with strength assessments, but several were useful in evaluating body composition changes during resistance training programs. Calculations for the assessment of relative body fat were based on skinfold measurements. Consolazio (12:256) stated that refinements were made in skinfold measurements since Brožek and Keys originally published their equations. The quality of calipers used to measure skin thickness was improved significantly, but a conservative attitude needed to be maintained about their use. He emphasized the need for all measurements to be performed by one person, and for all measurements to be made in the early morning. Variation in body hydration during the day increased thickness by up to fifteen percent. Shaver (48:75) stated that the percentage of body fat and its distribution were sex-linked, and that separate sites for measurements existed. In females, the most accurate measurements were derived from an oblique angle of the suprailiac skinfold, and from the back of the arm midway between the acromion and olecranon processes, with the elbow extended. (48:75) These measurements were used to calculate body density and percent of fat. Various investigators derived formulas for calculating these determinants of body composition. Wilmore and Behnke (62:268) listed the numerous authors accredited for their formulas, although Brožek was the best known. Sloan and Weir's (49:221) formulas for calculations were utilized in Exercise Physiology Laboratory sessions at Western Michigan University, and were used in the study.

$$D_B \text{ (Body density)} = 1.0764 - \left[0.00081 \times \text{supra-iliac skinfold}\right] - \left[0.00088 \times \text{triceps skinfold}\right]$$

$$\text{Fat Percentage} = \left[\frac{4.570}{D_B} - 4.142\right] \times 100$$

The measurement of limb girths or circumferences indicated the positive or negative concern of becoming "musclebound." Sylvester (52:15) stressed the use of a Gulik steel tape to measure girths. This eliminated possible stretching of the tape.

The study designed by Pipes and Wilmore (42:44) to measure strength improvement of males in isotonic and isokinetic training, assessed body composition changes. One group acted as a control, one group trained isotonically, and two groups trained isokinetically, at low and high speeds. All groups gained in total body weight, although the differences were not significant. All groups exhibited an increase in lean body weight, with a significant difference for the isotonic and isokinetic-high speed groups. All training groups decreased significantly in absolute fat, with the high speed group experiencing the greatest loss. Skinfold thickness at seven sites decreased for all training groups, with the high speed group significantly different for all seven sites. Changes in limb circumference resulted from training. The circumference of the arms and legs increased, whereas the circumference of the hips decreased for all training groups.

The study designed by Mayhew and Gross (32:433) measured anthropometric changes in twenty-seven college females in a resistance training program. They found significant increases in lean body mass, extended biceps, and forearm girths as a result of resistance training. Relative fat was significantly decreased, whereas skinfold thickness and body weight were not affected. Mayhew and Gross substantiated the increase in girth of the arms reflecting muscle hypertrophy. They found no increase in the girth of the thigh, but maintained that it was not a direct assessment of the muscle in cross section.

Mathews and Fox (31:475) summed up the changes in female body composition, attributable to a program of resistance training:

1) Significant losses of relative and absolute

body fat were observed.

2) A significant gain was observed in lean body weight, i.e. muscle.

3) Little change in total body weight was noted.

Isotonic Resistance Training

Mathews and Fox (31:135) stated that isotonic resistance training utilized the principle of dynamic contraction. The external resistance remained constant, but muscular tension varied through the range of motion of the joint. Williams and Stutzman (60:148) recognized that maximal tension occurred at the resting muscle length, and that tension declined as the muscle contracted. The concurrent use of bones as levers provided "an angle of application of muscle force" with mid-range efficiency and a resultant decrease of the load on the muscle. The internal resistance to the muscle fluctuated as a result of the leverage system. The overloading of a specific muscle was accomplished to a limited degree, i.e. at either end of the range of motion. (20:115) Isotonic resistance training limited the subject to a maximal external resistance moved through the weakest angle of pull. (34:1101)

Ariel (3) based his concept of variable resistance isotonic exercise on the biomechanical principle of moment curves, or the modifying effects of the lever system on muscular resistance. By definition, (3) "the moment of a force about any point is equal to the magnitude of the force multiplied by the perpendicular distance from the action line of the force to that point." The principle of moment curves dealt with the force needed to move a resistance, when the force or lever arm varied in distance from the point of rotation. The Universal Variable Resistance Machine was designed by Ariel to vary the magnitude of the external resistance as the lever arm changed through the range of motion. A relatively constant moment curve was attained by varying the resistance to achieve optimal muscular training through the full range of motion.

The initial advocates of an isotonic training program were DeLorme and Watkins in 1948 (4:140) with the introduction of a Progressive Resistance Program based on repetition maximum (RM). Their program utilized a ten RM, or the maximal resistance that was completed for ten repetitions before fatiguing. The training was performed in sets based on the ten RM load, as follows:

First set - ten repetitions at one-half ten RM load

Second set - ten repetitions at three-fourths ten RM load

Third set - ten repetitions at full ten RM load

Capen (6:132) designed a study to determine the most effective method of resistance training. Contrary to general usage, he referred to EM (execution maximum) instead of RM. In his study of 159 male freshmen, Capen found that all methods were variations of a few basic programs. These ranged from the type using extremely heavy resistance performed with one execution, to the type using moderately heavy resistance allowing up to fifteen executions. Capen concluded that the program with the heaviest resistance that permitted five executions was superior for strength development.

In his study of 177 males, Berger (5:179) examined the effectiveness of varying repetitions and sets for increasing strength. He concluded that the most effective Progressive Resistance Program was performance of a six RM for three sets. Berger stressed that an increase in repetitions per set wasted time, but that performing fewer sets and repetitions did not increase strength.

The schedule of training was investigated by Peterson (40:50) in his study of cadet corps males. Although DeLorme and Watkins initially advocated four consecutive days of training, Peterson advised three alternate days per week for an eight-week period. He found an increase in fifty-eight percent of overall strength in each subject in less than six weeks of training.

Although a variety of programs using different sets and repetitions were designed by researchers, the factor of overloading was irrefutable for strength development. Jones (25) maintained that only high intensity exercise developed strength. He exhorted trainees to complete their allotted number of repetitions, because only the final one represented maximal intensity effort. During the initial repetitions the intensity was low because the capacity existed to lift greater weight, but the intensity steadily progressed as the trainee weakened. Avoidance of the final productive repetition reduced training effect. Hettinger (18:26) stated that the intensity of the training stimulus must be increased proportional to maximal muscle strength. The trainee worked at increasing the number of repetitions in the final set. The attainment of a specified number of repetitions resulted in increasing the resistance to maintain overload.

Isokinetic Resistance Training

Isokinetic exercise was identified as accommodating resistance exercise, (45:471; 53:280; 55:319) due to the matching of the applied force to the specific muscle capacity at each angle of movement. Perrine (39:42) recognized that isokinetic exercise was a form of concentric contraction in which the resistance was proportional to the dynamic force of the muscle. Isokinetic exercise was based on the control of speed during a contraction (45:471) rather than on the quantity of external resistance. This was provided by machines with selectable speeds to control and limit acceleration. The prevention of acceleration of the limb was not negated by increased force, and resulted in the energy of dynamic tension being absorbed. Hislop and Perrine, (20:116) in their paper explaining the concept of isokinetic exercise, stressed the advantage of the constant overloading of a muscle. The absorbed energy was converted to a resistance proportional to the degree of exerted force. The magnitude of muscular force varied, relative to leverage efficiency, but maximal contraction was maintained due to the proportionally increased resistance.

Thistle, et al, (53:279) studied normal subjects in a preliminary investigation followed by a clinical study of hemiplegic patients in their evaluation of isokinetic exercise. Isokinetic training accomplished the major objective of resistance exercise. The application of resistance achieved maximal muscle load. The researchers emphasized that the return movement did not require an eccentric contraction of the prime mover. The opposite muscle group, or prime stopper, was maximally loaded on the return movement.

Perrine, (39:42) in his paper analyzing mechanical energy potentials, recognized the ability of the isokinetic machine to function as a "true dynamometer." The external output of a muscle, i.e. torque, work, power, and range of motion were measured at performance speeds. Osternig (37:152) and Osternig, et al (38:254) in separate studies of male football players, identified torque as the product of a force that acted around an axis of rotation, times the perpendicular distance from the axis. Moffroid and Kusiak (34:1099) defined the other parameters of measurement as: work - force acting through the distance of angular displacement, power - rate of doing work, and range of motion - angular displacement along an arc.

Hellebrandt and Houtz (17:319) in their study of six normal adult females, found the rate of working to be the critical variable in a training program. They experimented with increased pacing of training in comparison to increased resistance, and concluded that pacing offered a greater overload.

Moffroid, et al (33:745) based their study of thirty normal subjects on the relationship of velocity and tension, and found that torque values decreased with increased velocities. The point of optimum performance of muscle tension was passed at higher speeds and resulted in the peak of torque occurring later in the range. They concluded that muscle torque was increased through a specific arc by selective speed control to produce optimal power output.

Rosentswieg, et al (45:473) in their study of eleven females, compared electromyographic tracings obtained at three speeds of isokinetic contraction. They observed a greater muscle action potential at the slower speeds of contraction. They concluded that fast settings did not allow maximal accommodation to occur and therefore did not provide as much resistance.

Pipes and Wilmore (41:265; 42:43) assessed the variable speeds of an isokinetic machine in the specificity of training matched to speed during performance. They compared four groups of adult men: an isokinetic low speed, an isokinetic high speed, an isotonic group, and a control group. The isotonic group trained with constant, rather than variable resistance exercise. All groups were measured for static and dynamic muscular strength. Dynamic strength was assessed in three ways: one RM determined isotonically, isokinetically with a Cybex device at two speeds, and isokinetically with a Lumex device at two speeds. They found that both isokinetic groups increased significantly in static strength, although the isotonic group did show some improvement. Isotonic measurements showed that all groups increased over the control group; and isokinetic measurements indicated the high speed group had greater strength gains than the low speed group. The isotonic group showed no significant increases in strength gains when assessed isokinetically.

Hinson and Rosentsweig, (19:72) in their study of fifty-two college females, used electromyographic values to compare the number of motor units employed as a measure of maximal contraction. They concluded that, although the difference was not significant, isokinetic contraction produced greater muscle action potentials for the most subjects.

Hinson and Rosentsweig (19:72) stated that an evaluation of comparative strength gain was biased by the method of training. A group trained with one type of exercise often achieved a significant gain due to the specificity of the testing procedure. Recognizing the specificity involved, several investigators assessed strength on the machine used for training. Thorstensson, et al (56:12) used twenty-five male volunteers, and Johnson and Siegel (24:88) used forty female volunteers to objectively evaluate dynamic strength, with the Cybex II device.

Summary of the Related Literature

Resistance training was found to result in increases in muscle hypertrophy, strength, and endurance. These increases were achieved with Progressive Resistance Exercise, based on the principle of continuously overloading the muscle. Although most resistance training programs used male subjects, the "strength potential" existed in the female for increasing strength through training. The comparable quality of muscle tissue in the female did not lead to extreme hypertrophy due to the lack of the sex hormone, testosterone. Anthropometric measures were used to follow changes in body measurements resulting from resistance training programs. Calculation of body fat percentage indicated changes in lean body weight; and the measurement of limb girths permitted a check on hypertrophy of muscle tissue.

Isotonic training programs were based on dynamic contractions. The tension in the muscle varied through the range of motion due to the interaction of the muscle with the bones acting as levers. Specifically designed variable resistance machines attempted to limit the loss of overload in the mid-range of motion. The utilization of biomechanical principles to achieve a relatively constant moment curve, allowed optimal resistance throughout the range. Isotonic training programs varied in their structure, but overloading was the one accepted principle in designing a program. Optimal strength development resulted from a six repetition maximum (six RM) performed in three sets, and based on a schedule of three alternate days per week for an eight-week period. By applying the overload principle, the resistance was increased when the subject performed more than six repetitions in the final set.

Isokinetic training programs were based on contractions in which the resistance was proportional to the dynamic force of the muscle. The control of speed on the isokinetic machine limited acceleration in the mechanically efficient mid-range region of contraction. This limitation caused a proportional increase in resistance to the muscle, thereby maintaining the overload.

The isokinetic machine was used in the measurement of strength, as well as in the development of strength. Specificity indicated that strength measurements reflected the nature of the training program used for strength development.

CHAPTER III

DESIGN AND METHODOLOGY

This chapter contains four sections dealing with the construction of the research project: General Procedures, Isotonic Testing and Treatment, Isokinetic Testing and Treatment, and Data Analysis.

General Procedures

This study was designed to assess the effects of two programs of resistance training on strength development and body composition of college females. An Isotonic Variable Resistance group was compared to an Isokinetic group for gain in strength following an eight-week training program. The training program was designed to increase strength in the upper arms and legs of the subjects. The muscles trained were the biceps brachii and triceps brachii of the arms, and the quadriceps femoris and hamstrings of the legs. Strength tests identified the muscles trained with their function in limb movement, i.e. biceps - arm flexion, triceps - arm extension, quadriceps - leg extension, and hamstrings - leg flexion.

Anthropometric measurements were taken initially and finally to assess changes in body composition as a result of resistance training. Changes in body fat and the development of muscle hypertrophy without excessive gain in limb girths were analyzed.

The sample of the study was drawn from the population of non-activity physical education and recreation classes held in Gary Center of Western Michigan University during the winter semester of 1979. The names of thirty-seven volunteers were placed in a box, and the first thirty randomly drawn names determined the subjects of the study. Various factors resulted in three subjects being dropped from the study, but the reserve list of volunteers provided additional randomly selected subjects. The subjects were arbitrarily numbered and a table of random numbers (58:216) was used for assignment of fifteen subjects to a group. Tossing a coin was the method for assignment of each group to a training regime. After the first week, one subject was dropped from the Isotonic group, following her doctor's orders.

The subjects were initially assessed anthropometrically for the following items: height and weight, limb circumference of the upper arms and thighs, and skinfold measurements of the triceps and suprailiac areas. Measurements of the bust, waist, and hips were included but were not statistically analyzed. Initial measurements were made during the week prior to the start of the eight-week training program, and all measurements were made by the researcher to eliminate individual assessment differences. The subjects were measured before eleven A.M. to minimize hydration variations in assessments. (12:256) Final measurements were performed during the week following the training program.

Height and weight were assessed on a physician's scale. Limb circumference was measured using a spring-loaded Gulik steel tape. The circumference of the largest portion of each biceps was measured with the arm in an upright flexed position. The circumference of each thigh was measured in the standing position with body weight evenly distributed on both feet. The assessment was made at a point halfway between the crest of the ilium and the patella.

Skinfold determinations were performed with Lange calipers, in the following manner: all measurements were made on the right side of the body; the calipers were applied one centimeter from the thumb and index finger holding the fold of skin; and three separate appraisals were made of each area. Body density and body fat percentages were calculated from the skinfold values using the following formulas:

$$D_B = 1.0764 - \left[0.00081 \times \text{supra-iliac skinfold}\right] - \left[0.00088 \times \text{triceps skinfold}\right]$$

Body density

$$\text{Percent of Fat} = \left[\frac{4.570}{D_B} - 4.142\right] \times 100$$

Strength testing was performed during the week prior to the start of the eight-week training program. The researcher supervised the testing of each subject. Strength testing procedures will be discussed in the sections dealing with testing and treatment.

Isotonic Testing and Treatment

The measurement of strength of the Isotonic group was based on a six RM. The final repetition represented the ultimate struggle in completion. If the subject performed more than six repetitions, the resistance was increased; completion of less than six repetitions necessitated a decrease in resistance. The weight in pounds for the initial six RM load was recorded as the initial strength assessment for the Isotonic group. The same procedure was followed for the final six RM strength assessment.

Each subject trained Monday, Wednesday and Friday. The researcher was available during each training session to answer questions, observe proper and safe techniques, and to assist in strength re-evaluations. The training program was designed based on the Progressive Resistance Program of DeLorme and Watkins, but modified to utilize the conclusions of Berger. (5) Three sets of each exercise were performed with rest intervals lasting no longer than one to two minutes between sets. The sets were performed in the following manner:

First set - six repetitions at one-half load of six RM

Second set - six repetitions at three-fourths load of six RM

Third set - six repetitions at six RM load

The importance of completing the final repetition of the last set was emphasized for effective training. The first two sets functioned as a warm-up so that set number three was functionally and efficiently performed.

As the subject increased strength during training, overloading was re-evaluated. When the subject completed ten repetitions in the final set, the training resistance was increased.

Four stations of the Universal Variable Resistance Machine were used during training. The Centurion II (Figure 1) was used for training the muscles of the arms; the Quadriceps-Hamstrings Unit was used for the muscles of the leg. Each station provided exercise for both arms or both legs simultaneously. Rest intervals of up to three minutes were prescribed between stations. The training bout consisted of the use of the following stations:

quadriceps station - leg extension, hamstrings station - leg flexion, biceps curl station - arm flexion, and military press station - arm extension.

The use of the quadriceps station and the hamstrings station exercised the major opposing muscles of the upper legs. The quadriceps exercise was performed in a seated position on the bench, with the padded bar resting on the instep of each foot. The bar was raised by maximal extension of the knee joints. (Figures 2 and 3) Alternately, the hamstrings were exercised by prone positioning on the bench, and maximal flexion of the knee joints in raising the bar. (Figures 4 and 5)

The use of the biceps curl station and military press station exercised the major opposing muscles of the upper arms. The biceps curl was performed in a standing position with the bar held by both hands, in a palms-up position, shoulder-width apart. The bar, which initially rested against the thighs was curled up to the shoulder-neck area by maximal flexion of the elbow joints. (Figures 6 and 7) With the available Universal model, the military press was chosen as the best alternative to exercise the triceps. The exercise was performed in a seated position, with the hands shoulder-width apart on the bar. The bar was pressed upward to full extension of the elbow joints. (2:110) (Figures 8 and 9)

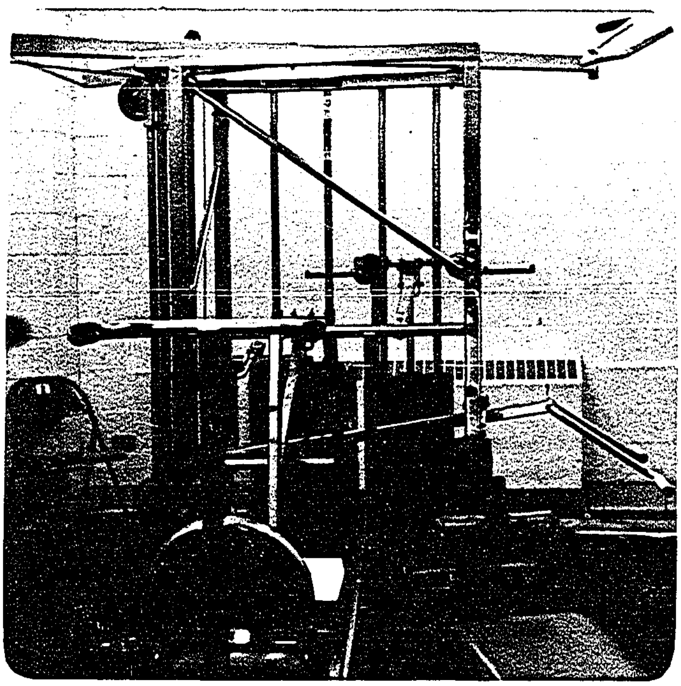

Figure 1. Isotonic Exercise
Universal Centurion II
Variable Resistance Machine

Figure 2. Isotonic Exercise
Starting Position for Leg Extension

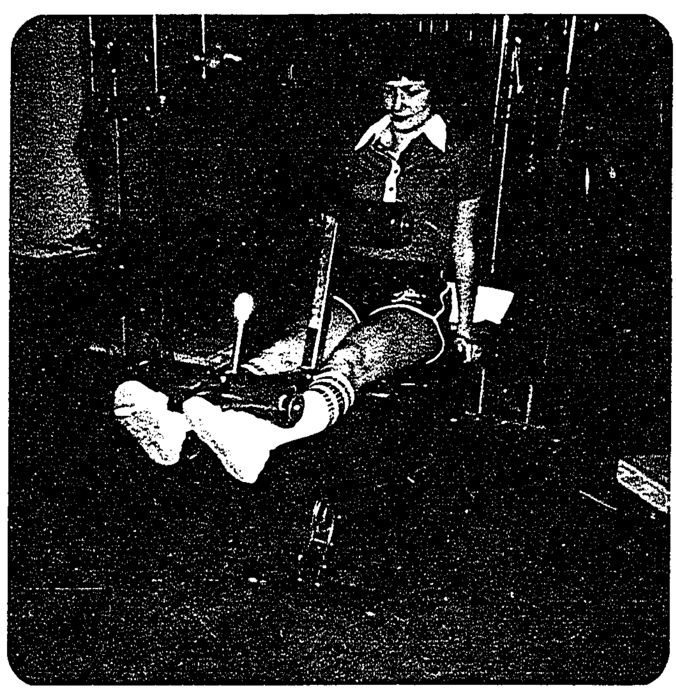

Figure 3. Isotonic Exercise
Maximal Extension of Leg

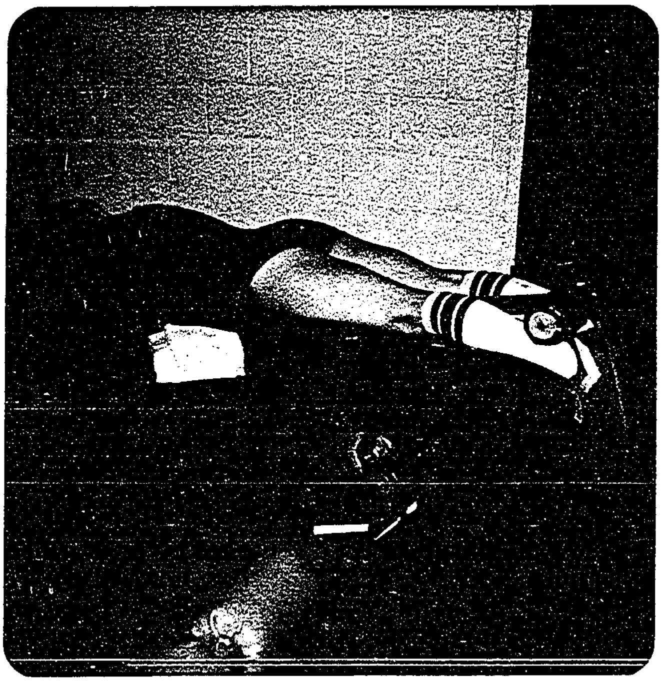

Figure 4. Isotonic Exercise
Starting Position for Leg Flexion

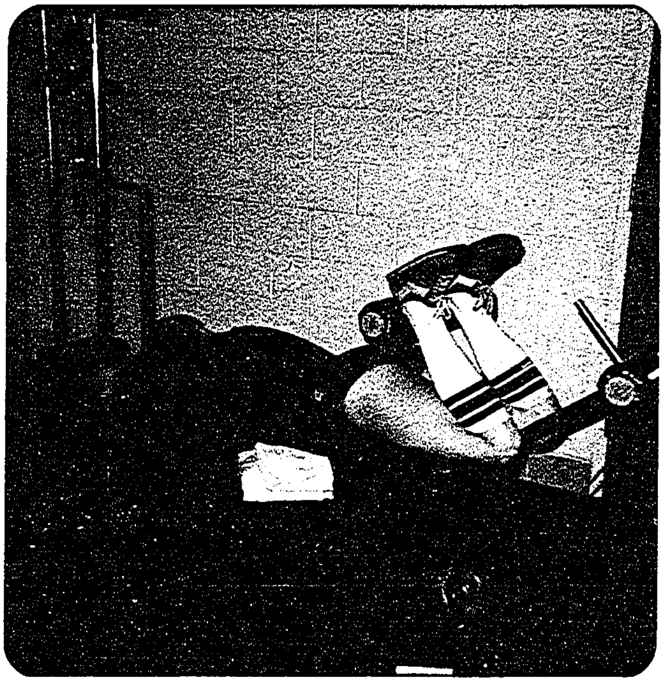

Figure 5. Isotonic Exercise
Maximal Flexion of Leg

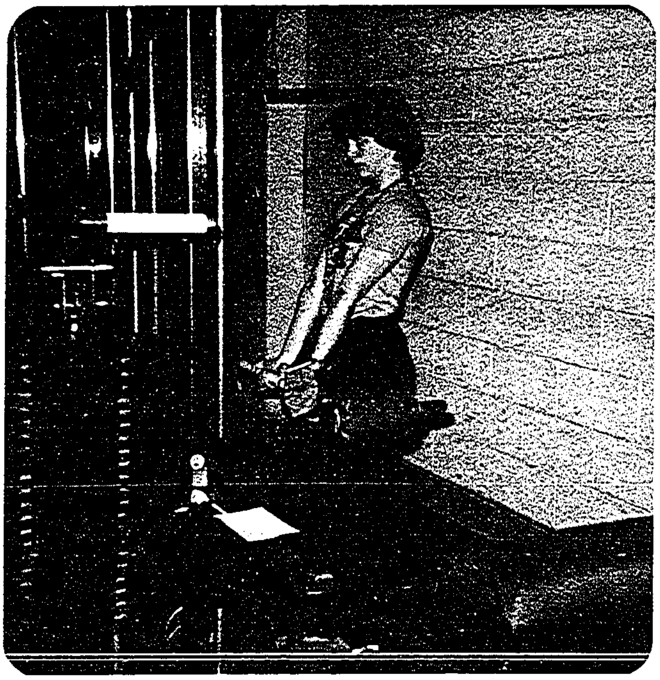

Figure 6. Isotonic Exercise
Starting Position for Arm Flexion

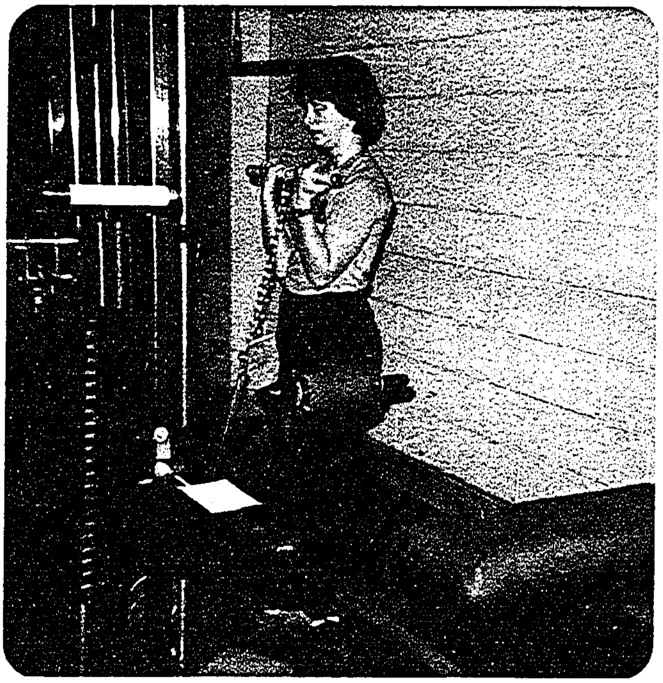

Figure 7. Isotonic Exercise
Maximal Flexion of Arm

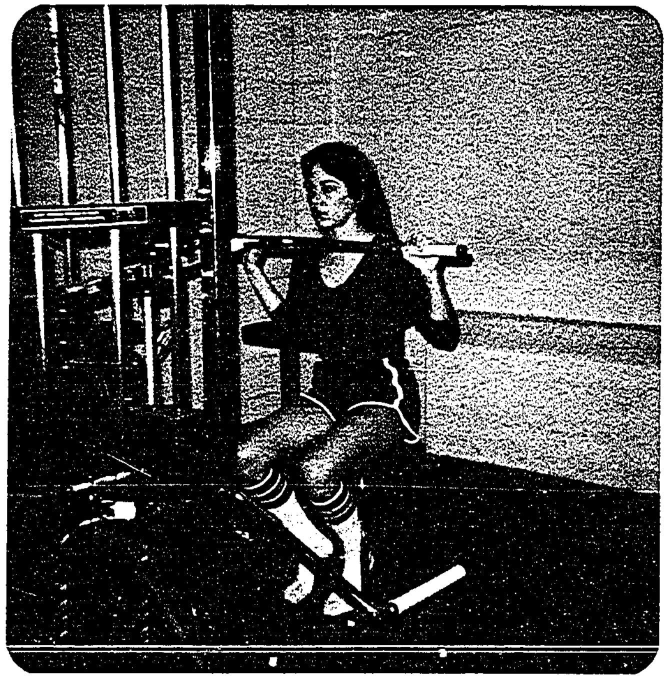

Figure 8. Isotonic Exercise
Starting Position for Arm Extension

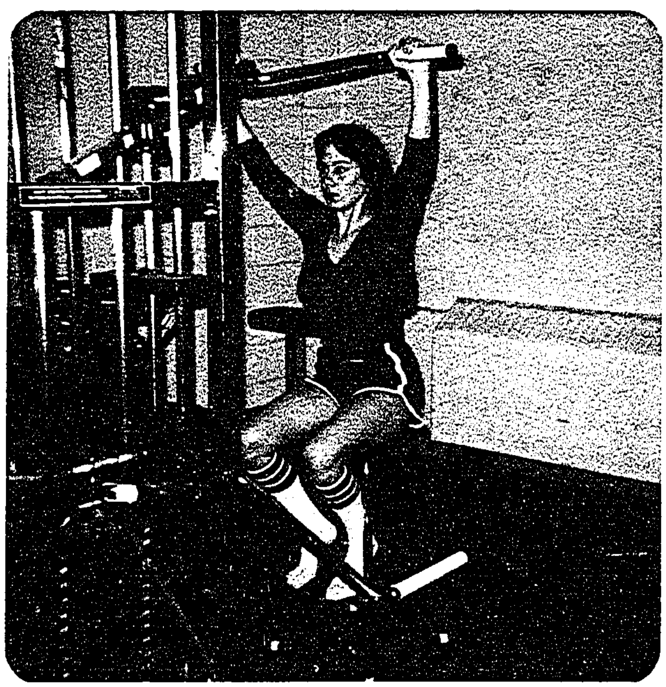

Figure 9. Isotonic Exercise
Maximal Extension of Arm

Isokinetic Testing and Treatment

The isokinetic machine used during the study was the Orthotron, Lumex Inc. order number 7120. (Figure 10) The system provided automatic accommodating resistance at controlled velocities of limb movement. Muscular output was measured at pre-selected velocities. Slow contractile velocity settings developed basic muscular strength whereas fast contractile velocity settings developed dynamic functional muscle power. Fast settings also offered quantification of endurance, or the ability to sustain high levels of muscular performance before fatiguing. (55:319) In this study, a slow contractile velocity setting was utilized to offer a basis of comparison to strength development in the Isotonic group.

The subject was positioned to align the axis of rotation of the joint controlling extension or flexion with the input axis of the Orthotron. (56:12) Knee testing was accomplished with the subject seated upright. (Figures 11 and 12) The knee was flexed to ninety degrees, and the force arm attached five centimeters above the ankle. A canvas strap was positioned and tightened ten centimeters above the patella to reduce hip flexion. (24:88) Elbow testing was performed with the subject seated, holding the force arm. (Figures 13 and 14) The elbow of the hand holding the force arm was rested on the

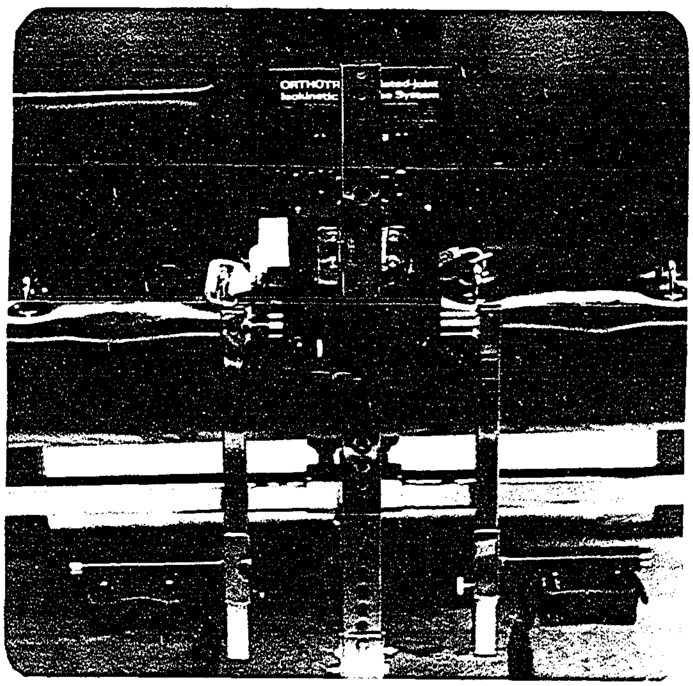

Figure 10. Isokinetic Exercise
Orthotron Machine

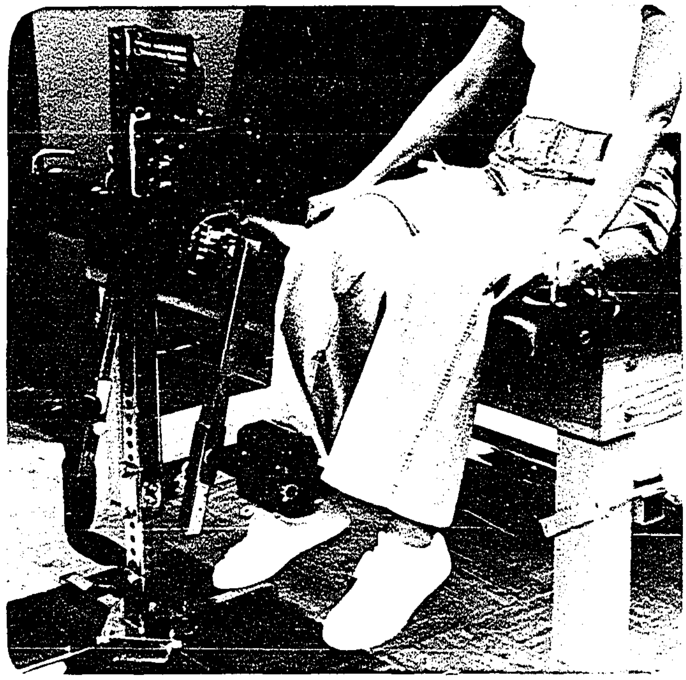

Figure 11. Isokinetic Exercise
Maximal Flexion of Leg

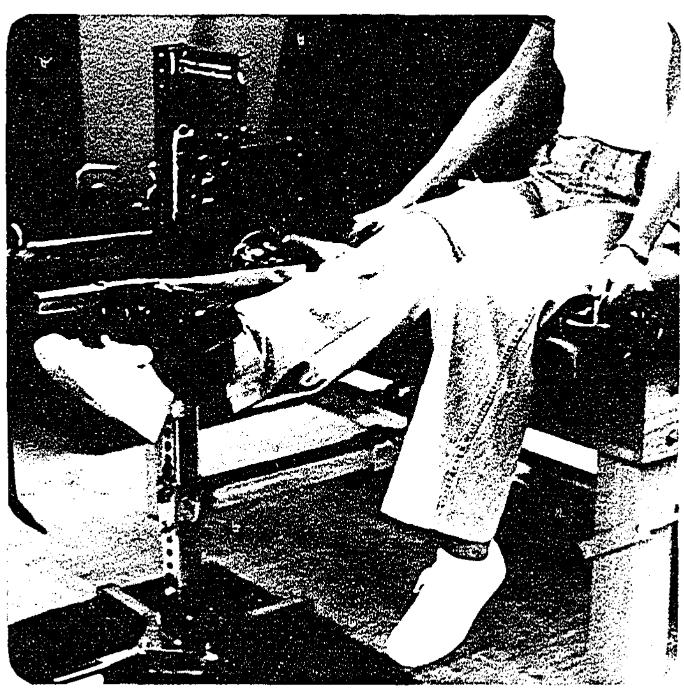

Figure 12. Isokinetic Exercise
Maximal Extension of Leg

Figure 13. Isokinetic Exercise
Maximal Flexion of Arm

Figure 14. Isokinetic Exercise
Maximal Extension of Arm

knee, and the elbow joint was stabilized with the opposite hand. The knee was flexed to approximately one hundred and twenty degrees, and provided a base of support for the arm.

The contractile velocity was adjusted to index number three or sixty degrees per second to test for strength. The subject performed two "practice" submaximal contractions. Testing was performed with six maximal contractions in each direction of rotation, i.e. extension and flexion. The measurement of strength was the highest value of torque attained in each direction of rotation, read directly from the set of dials in pounds.

The procedure of treatment was designed by Lumex, Inc., as a rehabilitation program, and adapted for use in the strength development program of the Isokinetic group. The positioning and velocity were identical to the testing protocol. Repetitions were increased to eighteen in three sets of six, with rest periods between sets.

Each subject trained Monday, Wednesday and Friday of each week, and the researcher was available during each session. Reassessment for overloading was not possible with the isokinetic program, because the subject worked against herself. An increase in strength values was the motivation for training.

The number of training stations was reduced to two for the Isokinetic group. Each station provided exercise for the opposing muscle groups. The knee station exercised the quadriceps during extension and the hamstrings during flexion; and the elbow station exercised the biceps during flexion and the triceps during extension.

It should be noted that some difficulty was experienced with the Orthotron during the measurement of arm extension. The difficulty was in the assessment dial for extension. The difference was corrected in the raw score value, by comparison of individual arm extension scores with another Orthotron machine.

Data Analysis

The experimental design of the study was controlled by statistically determining sample size. These procedures were described by Dotson and Kirkendall. (14:194) The choice of an accurate sample size controlled Type II errors. The level of tolerance of making a Type II error was set at twenty-five percent. The level of risk of Type I error was determined before collection of data. For this study, the level of confidence was set at five percent. Based on these confidence levels, the statistically significant differential between the means of improvement for each group was twenty pounds.

The study by Mayhew and Gross (32) was chosen for its population variability, the fourth factor in determining sample size. Their study dealt with twenty-seven females in a resistance training program. The subjects trained three days per week for nine weeks, using ten different isotonic exercises. The females were evaluated for strength changes in the biceps curl, bench press and leg press. The procedures by Mayhew and Gross differed from the design of this study in the use of two sets of a ten RM. The standard deviation of the initial mean for the leg press of the Mayhew and Gross study indicated a sample size of thirteen. This value was obtained from a table of sample size estimates. (14:290)

The data were analyzed at the computer center at Western Michigan University. The raw scores of each subject were coded by treatment group to separate the data for purposes of comparison.

The statistical technique employed to analyze the data was the t test for the mean difference between the initial and final values for each group. The correlated t test for related samples was used to analyze initial versus final scores within each group. The t test for independent samples was used to analyze the mean improvement score of the Isotonic group versus the mean improvement score of the Isokinetic group. The null hypothesis that the group means were equal was evaluated at the five percent level of confidence. Weber and Lamb (58:98) stated that the relevance of the t test depended on the following assumptions to ensure validity: (1) that the population from which the samples were drawn was normal, (2) that the selection of subjects was random and independent, (3) that homogeneity of variance was evident.

The assumption of homogeneity of variance of the samples was determined utilizing the F statistic. The F value was computed for the scores where a significant difference was established by the _t_ test. The assumption of equal variances was unnecessary for the correlated pairs (i.e. initial and final scores) derived from the same population. The null hypothesis that the variances of the two groups were equal was evaluated at the two percent level of significance.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

The purpose of this study was to compare the effect of Isotonic Resistance Training and Isokinetic Resistance Training in developing strength in female subjects, and to determine the effect of these resistance programs on changes in body composition based on anthropometric measurements. Specifically, the investigation compared the mean difference of initial and final strength scores for the Isotonic group; the mean difference of initial and final strength scores for the Isokinetic group; and the difference of mean improvement strength scores of the Isotonic versus the Isokinetic group. The following items were included in the analysis of strength scores: (1) Arm Extension - Right Arm, (2) Arm Extension - Left Arm, (3) Arm Flexion - Right Arm, (4) Arm Flexion - Left Arm, (5) Leg Extension - Right Leg, (6) Leg Extension - Left Leg, (7) Leg Flexion - Right Leg, (8) Leg Flexion - Left Leg. The strength scores of the Isotonic group were not divided into items for right and left limbs due to performance of the training with both limbs simultaneously. The analysis of data for the Isotonic group versus the Isokinetic group utilized this single score for each test item of the Isotonic group as a duplicate score for right and left limbs. The investigation also compared the mean difference of initial and final anthropometric scores for the Isotonic group; the mean difference of initial and final anthropometric scores for the Isokinetic group; and the difference of mean improvement anthropometric scores of the Isotonic versus the Isokinetic group. The following items were included in the analysis of anthropometric scores: (1) Weight, (2) Right Biceps, (3) Left Biceps, (4) Right Thigh, (5) Left Thigh, (6) Triceps Skinfold, (7) Suprailiac Skinfold, and (8) Percentage of Body Fat.

The data collected in this study were analyzed and comparisons made by the use of the t statistic. The correlated t test for related samples was used to analyze initial versus final scores for each group; and the t test for independent samples was used to analyze improvement scores between groups. The homogeneity of sample variance was tested by the F statistic. The equal variances assumption was unnecessary for the correlated pairs because they were derived from the same population.

The results and analyses are presented, with tables and discussion.

Analysis of Strength Scores for the Isotonic Group

Arm Extension

To compare the initial mean strength scores of the Isotonic group with their final mean strength scores in Arm Extension, the *t* test for correlated samples was used. Table 1 presents the strength scores, the means, the differences between the means, standard deviation, and the *t* value.

Table 1. Comparison of Initial and Final Strength Scores for Arm Extension of the Isotonic Group

Strength Scores	$\bar{X}$	Difference	S.D.	*t*
Initial	72.143	20.357	9.139	8.38*
Final	92.500		11.393	

*Significant at the .05 level of confidence

The mean strength scores for Arm Extension of the Isotonic group were 72.143 for the initial and 92.500 for the final. The difference of 20.357 pounds was significant at the .05 level of confidence.

With 13 degrees of freedom a *t* value greater than 2.160 was necessary to reject the null hypothesis. The obtained *t* value was 8.38. Therefore, the null hypothesis that the means were equal was rejected.

Arm Flexion

To compare the initial mean strength scores of the Isotonic group with their final mean strength scores in Arm Flexion, the *t* test for correlated samples was used. Table 2 presents the strength scores, the means, the differences between the means, standard deviation, and the *t* value.

Table 2. Comparison of Initial and Final Strength Scores for Arm Flexion of the Isotonic Group

Strength Scores	$\bar{X}$	Difference	S.D.	*t*
Initial	30.000	15.357	7.338	11.52*
Final	45.357		6.640	

*Significant at the .05 level of confidence

The mean strength scores for Arm Flexion of the Isotonic group were 30.000 for the initial and 45.357 for the final. The difference of 15.357 pounds was significant at the .05 level of confidence.

With 13 degrees of freedom a *t* value greater than 2.160 was necessary to reject the null hypothesis. The obtained *t* value was 11.52. Therefore, the null hypothesis that the means were equal was rejected.

Leg Extension

To compare the initial mean strength scores of the Isotonic group with their final mean strength scores in

Leg Extension, the t test for correlated samples was used. Table 3 presents the strength scores, the means, the differences between the means, standard deviation, and the t value.

Table 3. Comparison of Initial and Final Strength Scores for Leg Extension of the Isotonic Group

Strength Scores	$\overline{X}$	Difference	S.D.	t
Initial	41.786	60.357	14.624	15.75*
Final	102.143		20.164	

*Significant at the .05 level of confidence

The mean strength scores for Leg Extension of the Isotonic group were 41.786 for the initial and 102.143 for the final. The difference of 60.357 pounds was significant at the .05 level of confidence.

With 13 degrees of freedom a t value greater than 2.160 was necessary to reject the null hypothesis. The obtained t value was 15.75. Therefore, the null hypothesis that the means were equal was rejected.

Leg Flexion

To compare the initial mean strength scores of the Isotonic group with their final mean strength scores in Leg Flexion, the t test for correlated samples was used. Table 4 presents the strength scores, the means, the differences between the means, standard deviation, and the t value.

Table 4. Comparison of Initial and Final Strength Scores for Leg Flexion of the Isotonic Group

Strength Scores	$\bar{X}$	Difference	S.D.	t
Initial	27.857	20.000	8.708	11.02*
Final	47.857		6.419	

*Significant at the .05 level of confidence

The mean strength scores for Leg Flexion of the Isotonic group were 27.857 for the initial and 47.857 for the final. The difference of 20.000 pounds was significant at the .05 level of confidence.

With 13 degrees of freedom a t value greater than 2.160 was necessary to reject the null hypothesis. The obtained t value was 11.02. Therefore, the null hypothesis that the means were equal was rejected.

Summary of Data - Isotonic Group

Table 5 presents a summary of analyzed data for strength scores, the means, the differences between the means, standard deviation, and the t values of the Isotonic group.

Table 5. Summary Analyses of Data for Strength Scores of the Isotonic Group

Test Item	$\overline{X}$	Difference	S.D.	*t*
Arm Extension				
Initial	72.143	20.357	9.139	8.38*
Final	92.500		11.393	
Arm Flexion				
Initial	30.000	15.357	7.338	11.52*
Final	45.357		6.640	
Leg Extension				
Initial	41.786	60.357	14.624	15.75*
Final	102.143		20.164	
Leg Flexion				
Initial	27.857	20.000	8.708	11.02*
Final	47.857		6.419	

*Significant at the .05 level of confidence

The obtained *t* value was greater than 2.160 (13 degrees of freedom) for each test item. Therefore, the null hypothesis that the means were equal was rejected for each item. The rejection of the null hypothesis for each item indicates that isotonic resistance training significantly increased strength levels in the areas trained and tested.

Analysis of Strength Scores for the Isokinetic Group

Arm Extension - Right Arm

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in Right Arm Extension, the *t* test for correlated samples was used. Table 6 presents the strength scores, the means, the differences between the means, standard deviation, and the *t* value.

Table 6. Comparison of Initial and Final Strength Scores for Right Arm Extension of the Isokinetic Group

Strength Scores	$\bar{X}$	Difference	S.D.	*t*
Initial	9.533	21.467	6.289	8.83*
Final	31.000		9.599	

*Significant at the .05 level of confidence

The mean strength scores for Right Arm Extension of the Isokinetic group were 9.533 for the initial and 31.000 for the final. The difference of 21.467 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a *t* value greater than 2.145 was necessary to reject the null hypothesis. The obtained *t* value was 8.83. Therefore, the null hypothesis that the means were equal was rejected.

Arm Extension - Left Arm

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in Left Arm Extension, the _t_ test for correlated samples was used. Table 7 presents the strength scores, the means, the differences between the means, standard deviation, and the _t_ value.

Table 7. Comparison of Initial and Final Strength Scores for Left Arm Extension of the Isokinetic Group

Strength Scores	$\bar{X}$	Difference	S.D.	_t_
Initial	8.533	23.800	5.854	10.95*
Final	32.333		9.976	

*Significant at the .05 level of confidence

The mean strength scores for Left Arm Extension of the Isokinetic group were 8.533 for the initial and 32.333 for the final. The difference of 23.800 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a _t_ value greater than 2.145 was necessary to reject the null hypothesis. The obtained _t_ value was 10.95. Therefore, the null hypothesis that the means were equal was rejected.

Arm Flexion - Right Arm

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in

Right Arm Flexion, the t test for correlated samples was used. Table 8 presents the strength scores, the means, the differences between the means, standard deviation, and the t value.

Table 8. Comparison of Initial and Final Strength Scores for Right Arm Flexion of the Isokinetic Group

Strength Scores	$\bar{X}$	Difference	S.D.	t
Initial	29.067	27.533	9.975	8.31*
Final	56.600		14.807	

*Significant at the .05 level of confidence

The mean strength scores for Right Arm Flexion of the Isokinetic group were 29.067 for the initial and 56.600 for the final. The difference of 27.533 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 8.31. Therefore, the null hypothesis that the means were equal was rejected.

Arm Flexion - Left Arm

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in Left Arm Flexion, the t test for correlated samples was used. Table 9 presents the strength scores, the means, the difference between the means, standard deviation, and the t value.

Table 9. Comparison of Initial and Final Strength Scores for Left Arm Flexion of the Isokinetic Group

Strength Scores	$\bar{X}$	Difference	S.D.	t
Initial	24.800	33.533	7.223	7.59*
Final	58.333		15.430	

*Significant at the .05 level of confidence

The mean strength scores for Left Arm Flexion of the Isokinetic group were 24.800 for the initial and 58.333 for the final. The difference of 33.533 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 7.59. Therefore, the null hypothesis that the means were equal was rejected.

Leg Extension - Right Leg

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in Right Leg Extension, the t test for correlated samples was used. Table 10 presents the strength scores, the means, the differences between the means, standard deviation, and the t value.

Table 10. Comparison of Initial and Final Strength Scores for Right Leg Extension of the Isokinetic Group

Strength Scores	$\overline{X}$	Difference	S.D.	*t*
Initial	121.533	37.333	21.850	6.05*
Final	158.867		27.859	

*Significant at the .05 level of confidence

The mean strength scores for Right Leg Extension of the Isokinetic group were 121.533 for the initial and 158.867 for the final. The difference of 37.333 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a *t* value greater than 2.145 was necessary to reject the null hypothesis. The obtained *t* value was 6.05. Therefore, the null hypothesis that the means were equal was rejected.

Leg Extension - Left Leg

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in Left Leg Extension, the *t* test for correlated samples was used. Table 11 presents the strength scores, the means, the differences between the means, standard deviation, and the *t* value.

Table 11. Comparison of Initial and Final Strength Scores for Left Leg Extension of the Isokinetic Group

Strength Scores	$\overline{X}$	Difference	S.D.	t
Initial	123.133	40.933	22.315	5.95*
Final	164.067		28.860	

*Significant at the .05 level of confidence

The mean strength scores for Left Leg Extension of the Isokinetic group were 123.133 for the initial and 164.067 for the final. The difference of 40.933 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a *t* value greater than 2.145 was necessary to reject the null hypothesis. The obtained *t* value was 5.95. Therefore, the null hypothesis that the means were equal was rejected.

Leg Flexion - Right Leg

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in Right Leg Flexion, the *t* test for correlated samples was used. Table 12 presents the strength scores, the means, the differences between the means, standard deviation, and the *t* value.

Table 12. Comparison of Initial and Final Strength Scores for Right Leg Flexion of the Isokinetic Group

Strength Scores	$\bar{X}$	Difference	S.D.	t
Initial	101.000	23.000	18.182	4.65*
Final	124.000		17.829	

*Significant at the .05 level of confidence

The mean strength scores for Right Leg Flexion of the Isokinetic group were 101.000 for the initial and 124.000 for the final. The difference of 23.000 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a _t_ value greater than 2.145 was necessary to reject the null hypothesis. The obtained _t_ value was 4.65. Therefore, the null hypothesis that the means were equal was rejected.

Leg Flexion - Left Leg

To compare the initial mean strength scores of the Isokinetic group with their final mean strength scores in Left Leg Flexion, the _t_ test for correlated samples was used. Table 13 presents the strength scores, the means, the differences between the means, standard deviation, and the _t_ value.

Table 13. Comparison of Initial and Final Strength Scores for Left Leg Flexion of the Isokinetic Group

Strength Scores	$\overline{X}$	Difference	S.D.	t
Initial	97.333	26.733	17.095	5.10*
Final	124.067		17.609	

*Significant at the .05 level of confidence

The mean strength scores for Left Leg Flexion of the Isokinetic group were 97.333 for the initial and 124.067 for the final. The difference of 26.733 pounds was significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 5.10. Therefore, the null hypothesis that the means were equal was rejected.

Summary of Data - Isokinetic Group

Table 14 presents a summary of analyzed data for strength scores, the means, the differences between the means, standard deviation, and the t values of the Isokinetic group.

Table 14. Summary Analyses of Data for Strength Scores of the Isokinetic Group

Test Item	$\bar{X}$	Difference	S.D.	*t*
Arm Extension - Right Arm				
Initial	9.533	21.467	6.289	8.83*
Final	31.000		9.599	
Arm Extension - Left Arm				
Initial	8.533	23.800	5.854	10.95*
Final	32.333		9.976	
Arm Flexion - Right Arm				
Initial	29.067	27.533	9.975	8.31*
Final	56.600		14.807	
Arm Flexion - Left Arm				
Initial	24.800	33.533	7.223	7.59*
Final	58.333		15.430	
Leg Extension - Right Leg				
Initial	121.533	37.333	21.850	6.05*
Final	158.867		27.859	
Leg Extension - Left Leg				
Initial	123.133	40.933	22.315	5.95*
Final	164.067		28.860	
Leg Flexion - Right Leg				
Initial	101.000	23.000	18.182	4.65*
Final	124.000		17.829	
Leg Flexion - Left Leg				
Initial	97.333	26.733	17.095	5.10*
Final	124.067		17.609	

*Significant at the .05 level of confidence

The obtained t value was greater than 2.145 (14 degrees of freedom) for each test item. Therefore, the null hypothesis that the means were equal was rejected for each item. The rejection of the null hypothesis for each item indicates that Isokinetic resistance training significantly increased strength levels in the areas trained and tested.

Analysis of Mean Improvement Strength Scores (Final - Initial) for the Isotonic Group Versus the Isokinetic Group

Arm Extension - Right Arm

To compare the mean improvement strength score of the Isotonic group with the mean improvement strength score of the Isokinetic group for Right Arm Extension, the t test for independent samples was used. Table 15 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 15. Comparison of Mean Improvement Strength Scores for Right Arm Extension of the Isotonic Group and Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	20.357	1.110	9.086	0.32
Isokinetic	21.467		9.418	

The mean improvement scores for Right Arm Extension were 20.357 for the Isotonic group and 21.467 for the

Isokinetic group. The difference of 1.110 pounds was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 0.32. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Arm Extension - Left Arm

To compare the mean improvement strength score of the Isotonic group with the mean improvement strength score of the Isokinetic group for Left Arm Extension, the t test for independent samples was used. Table 16 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 16. Comparison of Mean Improvement Strength Scores for Left Arm Extension of the Isotonic Group and Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	20.357	3.443	9.086	1.06
Isokinetic	23.800		8.419	

The mean improvement scores for Left Arm Extension were 20.357 for the Isotonic group and 23.800 for the Isokinetic group. The difference of 3.443 pounds was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 1.06. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Arm Flexion - Right Arm

To compare the mean improvement strength score of the Isotonic group with the mean improvement strength score of the Isokinetic group for Right Arm Flexion, the t test for independent samples was used. Table 17 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 17. Comparison of Mean Improvement Strength Scores for Right Arm Flexion of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	15.357	12.176	4.986	3.32*
Isokinetic	27.533		12.839	

*Significant at the .05 level of confidence

The mean improvement scores for Right Arm Flexion were 15.357 for the Isotonic group and 27.533 for the Isokinetic group. The difference of 12.176 pounds was significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 3.32. Therefore, the null hypothesis that the means were equal was rejected.

Table 18 shows the variances, the degrees of freedom and the F value obtained for Right Arm Flexion using 29 subjects.

Table 18. Test for Homogeneity of Variance in the Right Arm Flexion Test Item

Group	Variance	df	F
Isotonic	24.860	13	6.63
Isokinetic	164.840	14	

The assumption of homogeneity of variance was tested using the F statistic. The null hypothesis that the variances of the two groups were equal was tested. The variance of the Isotonic group was 24.860, while the variance of the Isokinetic group was 164.840. With 14 and 13 degrees of freedom, an F value greater than 3.87 was necessary to reject the null hypothesis. The obtained F value was 6.63. Therefore, the null hypothesis that there was no significant difference between the variances of the two groups was rejected.

<u>Arm Flexion - Left Arm</u>

To compare the mean improvement strength score of the

Isotonic group with the mean improvement strength score of the Isokinetic group for Left Arm Flexion, the t test for independent samples was used. Table 19 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 19. Comparison of Mean Improvement Strength Scores for Left Arm Flexion of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	15.357	18.176	4.986	3.82*
Isokinetic	33.533		17.121	

*Significant at the .05 level of confidence

The mean improvement scores for Left Arm Flexion were 15.357 for the Isotonic group and 33.533 for the Isokinetic group. The difference of 18.176 pounds was significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 3.82. Therefore, the null hypothesis that the means were equal was rejected.

Table 20 shows the variances, the degrees of freedom and the F value obtained for Left Arm Flexion using 29 subjects.

Table 20. Test for Homogeneity of Variance in the Left Arm Flexion Test Item

Group	Variance	df	F
Isotonic	24.860	13	11.79
Isokinetic	293.129	14	

The assumption of homogeneity of variance was tested using the F statistic. The null hypothesis that the variances of the two groups were equal was tested. The variance of the Isotonic group was 24.860, while the variance of the Isokinetic group was 293.129. With 14 and 13 degrees of freedom, an F value greater than 3.87 was necessary to reject the null hypothesis. The obtained F value was 11.79. Therefore, the null hypothesis that there was no significant difference between the variances of the two groups was rejected.

Leg Extension - Right Leg

To compare the mean improvement strength score of the Isotonic group with the mean improvement strength score of the Isokinetic group for Right Leg Extension, the *t* test for independent samples was used. Table 21 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the *t* value.

Table 21. Comparison of Mean Improvement Strength Scores for Right Leg Extension of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	60.357	23.024	14.340	3.12*
Isokinetic	37.333		23.895	

*Significant at the .05 level of confidence

The mean improvement scores for Right Leg Extension were 60.357 for the Isotonic group and 37.333 for the Isokinetic group. The difference of 23.024 pounds was significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 3.12. Therefore, the null hypothesis that the means were equal was rejected.

Table 22 shows the variances, degrees of freedom and the F value obtained for Right Leg Extension using 29 subjects.

Table 22. Test for Homogeneity of Variance in the Right Leg Extension Test Item

Group	Variance	df	F
Isotonic	205.636	13	2.78*
Isokinetic	570.971	14	

*Significant at the .02 level of confidence

The assumption of homogeneity of variance was tested using the F statistic. The null hypothesis that the variances of the two groups were equal was tested. The variance of the Isotonic group was 205.636, while the variance of the Isokinetic group was 570.971. With 14 and 13 degrees of freedom, an F value greater than 3.87 was necessary to reject the null hypothesis. The obtained F value was 2.78. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the variances of the two groups were equal.

Leg Extension - Left Leg

To compare the mean improvement strength score of the Isotonic group with the mean improvement strength score of the Isokinetic group for Left Leg Extension, the *t* test for independent samples was used. Table 23 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the *t* value.

Table 23. Comparison of Mean Improvement Strength Scores for Left Leg Extension of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	*t*
Isotonic	60.357	19.424	14.340	2.42*
Isokinetic	40.933		26.647	

*Significant at the .05 level of confidence

The mean improvement scores for Left Leg Extension were 60.357 for the Isotonic group and 40.933 for the Isokinetic group. The difference of 19.424 pounds was significant at the .05 level of confidence.

With 27 degrees of freedom a *t* value greater than 2.052 was necessary to reject the null hypothesis. The obtained *t* value was 2.42. Therefore, the null hypothesis that the means were equal was rejected.

Table 24 shows the variances, degrees of freedom, and the F value obtained for Left Leg Extension using 29 subjects.

Table 24. Test for Homogeneity of Variance in the Left Leg Extension Test Item

Group	Variance	df	F
Isotonic	205.636	13	3.45*
Isokinetic	710.063	14	

*Significant at the .02 level of confidence

The assumption of homogeneity of variance was tested using the F statistic. The null hypothesis that the variances of the two groups were equal was tested. The variance of the Isotonic group was 205.636, while the variance of the Isokinetic group was 710.063. With 14 and 13 degrees of freedom, an F value greater than 3.87 was necessary to reject the null hypothesis. The obtained F value was 3.45. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the variances of the two groups were equal.

Leg Flexion - Right Leg

To compare the mean improvement strength score of the Isotonic group with the mean improvement strength score of the Isokinetic group for Right Leg Flexion, the *t* test for independent samples was used. Table 25 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the *t* value.

Table 25. Comparison of Mean Improvement Strength Scores for Right Leg Flexion of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	*t*
Isotonic	20.000	3.000	6.794	0.55
Isokinetic	23.000		19.176	

The mean improvement scores for Right Leg Flexion were 20.000 for the Isotonic group and 23.000 for the Isokinetic group. The difference of 3.000 pounds was not significant at the .05 level of confidence.

With 27 degrees of freedom a *t* value greater than 2.052 was necessary to reject the null hypothesis. The obtained *t* value was 0.55. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Leg Flexion - Left Leg

To compare the mean improvement strength score of the Isotonic group with the mean improvement strength score of the Isokinetic group for Left Leg Flexion, the *t* test for independent samples was used. Table 26 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the *t* value.

Table 26. Comparison of Mean Improvement Strength Scores for Left Leg Flexion of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	*t*
Isotonic	20.000	6.733	6.794	1.18
Isokinetic	26.733		20.303	

The mean improvement scores for Left Leg Flexion were 20.000 for the Isotonic group and 26.733 for the Isokinetic group. The difference of 6.733 pounds was not significant at the .05 level of confidence.

With 27 degrees of freedom a *t* value greater than 2.052 was necessary to reject the null hypothesis. The obtained *t* value was 1.18. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Summary of Data - Isotonic Group and Isokinetic Group

Table 27 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the *t* values for all strength test items of the two groups.

Table 27. Summary Analyses of Data for Strength Test Items

Test Item	Mean Improvement Scores	S.D.	Improvement Mean Difference	t
Right Arm - Extension				
Isotonic Group	20.357	9.086	1.110	0.32
Isokinetic Group	21.467	9.418		
Left Arm - Extension				
Isotonic Group	20.357	9.086	3.443	1.06
Isokinetic Group	23.800	8.419		
Right Arm - Flexion				
Isotonic Group	15.357	4.986	12.176	3.32*
Isokinetic Group	27.533	12.839		
Left Arm - Flexion				
Isotonic Group	15.357	4.986	18.176	3.82*
Isokinetic Group	33.533	17.121		
Right Leg - Extension				
Isotonic Group	60.357	14.340	23.024	3.12*
Isokinetic Group	37.333	23.895		
Left Leg - Extension				
Isotonic Group	60.357	14.340	19.424	2.42*
Isokinetic Group	40.933	26.647		
Right Leg - Flexion				
Isotonic Group	20.000	6.794	3.000	0.55
Isokinetic Group	23.000	19.176		
Left Leg - Flexion				
Isotonic Group	20.000	6.794	6.733	1.18
Isokinetic Group	26.733	20.303		

*Significant at the .05 level of confidence

The obtained t value was less than 2.052 (27 degrees of freedom) for the test items of Arm Extension, Right and Left and of Leg Flexion, Right and Left. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal. The obtained t value was greater than 2.052 for the test items of Arm Flexion, Right and Left. Therefore, the null hypothesis that there was no significant difference between the means of the two groups was rejected. The significant difference was in favor of the Isokinetic Group. The obtained F value for homogeneity of variance was greater than 3.87 (14 and 13 degrees of freedom) for Arm Flexion, Right and Left. Therefore, the null hypothesis that there was no significant difference between the variances of the two groups was rejected.

The obtained t value was greater than 2.052 for the test items of Leg Extension, Right and Left. Therefore, the null hypothesis that there was no significant difference between the means of the two groups was rejected. In this case, the significant difference was in favor of the Isotonic Group. The obtained F value was less than 3.87 for Leg Extension, Right and Left. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the variances of the two groups were equal.

Analysis of Anthropometric Scores for the Isotonic Group

Weight

To compare the initial mean score with the final mean score for the Weight of the Isotonic group, the *t* test for correlated samples was used. Table 28 presents the scores for weight, the means, the differences between the means, standard deviation, and the *t* value.

Table 28. Comparison of Initial and Final Scores for Weight of the Isotonic Group

Weight Scores	$\bar{X}$	Difference	S.D.	*t*
Initial	59.300	0.655	4.535	3.02*
Final	59.955		4.755	

*Significant at the .05 level of confidence

The mean scores for Weight of the Isotonic Group were 59.300 for the initial and 59.955 for the final. The difference of 0.655 kg was significant at the .05 level of confidence.

With 13 degrees of freedom a *t* value greater than 2.160 was necessary to reject the null hypothesis. The obtained *t* value was 3.02. Therefore, the null hypothesis that the means were equal was rejected.

Right Biceps Circumference

To compare the initial mean score with the final mean score for the Right Biceps of the Isotonic group, the t test for correlated samples was used. Table 29 presents the scores for the right biceps, the means, the differences between the means, standard deviation, and the t value.

Table 29. Comparison of Initial and Final Scores for Right Biceps Circumference of the Isotonic Group

Right Biceps Scores	$\bar{X}$	Difference	S.D.	t
Initial	25.909	0.746	1.756	5.34*
Final	26.655		1.831	

*Significant at the .05 level of confidence

The mean scores for the Circumference of the Right Biceps of the Isotonic Group were 25.909 for the initial and 26.655 for the final. The difference of 0.746 cm was significant at the .05 level of confidence.

With 13 degrees of freedom, a t value greater than 2.160 was necessary to reject the null hypothesis. The obtained t value was 5.34. Therefore, the null hypothesis that the means were equal was rejected.

Left Biceps Circumference

To compare the initial mean score with the final mean score for the Left Biceps of the Isotonic group, the t test for correlated samples was used. Table 30 presents the scores for the left biceps, the means, the differences between the means, standard deviation, and the t value.

Table 30. Comparison of Initial and Final Scores for Left Biceps Circumference of the Isotonic Group

Left Biceps Scores	$\bar{X}$	Difference	S.D.	t
Initial	25.725	0.631	1.934	3.74*
Final	26.356		1.960	

*Significant at the .05 level of confidence

The mean scores for the Circumference of the Left Biceps of the Isotonic group were 25.725 for the initial and 26.356 for the final. The difference of 0.631 cm was significant at the .05 level of confidence.

With 13 degrees of freedom, a t value greater than 2.160 was necessary to reject the null hypothesis. The obtained t value was 3.74. Therefore, the null hypothesis that the means were equal was rejected.

Right Thigh Circumference

To compare the initial mean score with the final mean score for the Right Thigh of the Isotonic group, the t test for correlated samples was used. Table 31 presents the scores for the right thigh, the means, the differences between the means, standard deviation, and the t value.

Table 31. Comparison of Initial and Final Scores for Right Thigh Circumference of the Isotonic Group

Right Thigh Scores	$\bar{X}$	Difference	S.D.	t
Initial	54.255	-0.500	2.663	1.70
Final	53.755		2.756	

The mean scores for the Circumference of the Right Thigh of the Isotonic group were 54.255 for the initial and 53.755 for the final. The difference of -0.500 cm was not significant at the .05 level of confidence.

With 13 degrees of freedom, a t value greater than 2.160 was necessary to reject the null hypothesis. The obtained t value was 1.70. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Left Thigh Circumference

To compare the initial mean score with the final mean score for the Left Thigh of the Isotonic group, the t test for correlated samples was used. Table 32 presents the scores for the left thigh, the means, the differences between the means, standard deviation, and the t value.

Table 32. Comparison of Initial and Final Scores for Left Thigh Circumference of the Isotonic Group

Left Thigh Scores	$\overline{X}$	Difference	S.D.	t
Initial	54.057	-0.529	3.056	1.39
Final	53.529		2.717	

The mean scores for the Circumference of the Left Thigh of the Isotonic group were 54.057 for the initial and 53.529 for the final. The difference of -0.529 cm was not significant at the .05 level of confidence.

With 13 degrees of freedom, a t value greater than 2.160 was necessary to reject the null hypothesis. The obtained t value was 1.39. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Triceps Skinfold

To compare the initial mean score with the final mean score for the Triceps Skinfold of the Isotonic group, the t test for correlated samples was used. Table 33 presents the scores for the triceps skinfold, the means, the differences between the means, standard deviation, and the t value.

Table 33. Comparison of Initial and Final Scores for Triceps Skinfold Measurement of the Isotonic Group

Triceps Skinfold	$\bar{X}$	Difference	S.D.	t
Initial	19.834	-0.476	4.287	1.37
Final	19.357		5.030	

The mean scores for the Triceps Skinfold of the Isotonic group were 19.834 for the initial and 19.357 for the final. The difference of -0.476 mm was not significant at the .05 level of confidence.

With 13 degrees of freedom, a *t* value greater than 2.160 was necessary to reject the null hypothesis. The obtained *t* value was 1.37. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Suprailiac Skinfold

To compare the initial mean score with the final mean score for the Suprailiac Skinfold of the Isotonic group, the *t* test for correlated samples was used. Table 34 presents the scores for the suprailiac skinfold, the means, the difference between the means, standard deviation, and the *t* value.

Table 34. Comparison of Initial and Final Scores for Suprailiac Skinfold Measurement of the Isotonic Group

Suprailiac Skinfold	$\bar{X}$	Difference	S.D.	*t*
Initial	14.488	-0.095	3.535	0.20
Final	14.393		3.138	

The mean scores for the Suprailiac Skinfold of the Isotonic group were 14.488 for the initial and 14.393 for the final. The difference of -0.095 mm was not significant at the .05 level of confidence.

With 13 degrees of freedom, a *t* value greater than 2.160 was necessary to reject the null hypothesis. The obtained *t* value was 0.20. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Percent of Fat

To compare the initial mean score with the final mean score for Percent of Fat of the Isotonic group, the *t* test for correlated samples was used. Table 35 presents the scores for the fat percentage, the means, the difference between the means, standard deviation and the *t* value.

Table 35. Comparison of Initial and Final Scores for Percent of Fat Measurement of the Isotonic Group

Percent of Fat	$\overline{X}$	Difference	S.D.	t
Initial	22.200	-0.200	2.650	0.93
Final	22.000		2.790	

The mean scores for the Percent of Fat of the Isotonic group were 22.200 for the initial and 22.000 for the final. The difference of -0.200% was not significant at the .05 level of confidence.

With 13 degrees of freedom, a t value greater than 2.160 was necessary to reject the null hypothesis. The obtained t value was 0.93. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Summary of Data - Isotonic Group

Table 36 presents the scores for anthropometric data, the means, the difference between the means, standard deviation and the t values of the Isotonic group.

Table 36. Summary Analyses of Data for Anthropometric Scores of the Isotonic Group

Test Item	$\bar{X}$	Difference	S.D.	t
Weight				
Initial	59.300	0.655	4.535	3.02*
Final	59.955		4.755	
Right Biceps				
Initial	25.909	0.746	1.756	5.34*
Final	26.655		1.831	
Left Biceps				
Initial	25.725	0.631	1.934	3.74*
Final	26.356		1.960	
Right Thigh				
Initial	54.255	-0.500	2.663	1.70
Final	53.755		2.756	
Left Thigh				
Initial	54.057	-0.529	3.056	1.39
Final	53.529		2.717	
Triceps Skinfold				
Initial	19.834	-0.476	4.287	1.37
Final	19.357		5.030	
Suprailiac Skinfold				
Initial	14.488	-0.095	3.535	0.20
Final	14.393		3.138	
Percent of Fat				
Initial	22.200	-0.200	2.650	0.93
Final	22.000		2.790	

*Significant at the .05 level of confidence

The test items of Weight, Right Biceps Circumference, and Left Biceps Circumference showed an increase from Initial to Final measurement; whereas Right Thigh Circumference, Left Thigh Circumference, Triceps Skinfold, Suprailiac Skinfold, and Percent of Fat showed a decrease in measurement.

The obtained t value was less than 2.160 (13 degrees of freedom) for the test items of Right Thigh Circumference, Left Thigh Circumference, Triceps Skinfold, Suprailiac Skinfold, and Percent of Fat. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal. The obtained t value was greater than 2.160 for the test items of Weight, Right Biceps Circumference, and Left Biceps Circumference. Therefore, the null hypothesis that the means were equal was rejected. The rejection of the null hypothesis indicated that a significant difference was established between Initial and Final scores. The anthropometric test items of Weight, Right Biceps Circumference and Left Biceps Circumference showed a significant increase from the Initial to the Final measurement for the Isotonic group.

Analysis of Anthropometric Scores for the Isokinetic Group

Weight

To compare the initial mean score with the final mean score for the Weight of the Isokinetic group, the t test for correlated samples was used. Table 37 presents the scores for weight, the means, the differences between the means, standard deviation, and the t value.

Table 37. Comparison of Initial and Final Scores for Weight of the Isokinetic Group

Weight Scores	$\bar{X}$	Difference	S.D.	t
Initial	64.281	0.635	6.509	1.37
Final	64.916		6.105	

The mean scores for Weight of the Isotonic group were 64.281 for the initial and 64.916 for the final. The difference of 0.635 kg was not significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 1.37. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Right Biceps Circumference

To compare the initial mean score with the final mean score for the Right Biceps of the Isokinetic group, the t test for correlated samples was used. Table 38 presents the scores for the right biceps, the means, the differences between the means, standard deviation, and the t value.

Table 38. Comparison of Initial and Final Scores for Right Biceps Circumference of the Isokinetic Group

Right Biceps Scores	$\bar{X}$	Difference	S.D.	t
Initial	26.489	0.551	1.456	2.87*
Final	27.040		1.386	

*Significant at the .05 level of confidence

The mean scores for the Right Biceps of the Isokinetic group were 26.489 for the initial and 27.040 for the final. The difference of 0.551 cm was significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 2.87. Therefore, the null hypothesis that the means were equal was rejected.

Left Biceps Circumference

To compare the initial mean score with the final mean score for the Left Biceps of the Isokinetic group, the t test for correlated samples was used. Table 39 presents the scores for the left biceps, the means, the differences between the means, standard deviation, and the t value.

Table 39. Comparison of Initial and Final Scores for Left Biceps Circumference of the Isokinetic Group

Left Biceps Scores	$\bar{X}$	Difference	S.D.	*t*
Initial	26.699	0.316	1.723	1.39
Final	27.015		1.443	

The mean scores for the Left Biceps of the Isokinetic group were 26.699 for the initial and 27.015 for the final. The difference of 0.316 cm was not significant at the .05 level of confidence.

With 14 degrees of freedom a *t* value greater than 2.145 was necessary to reject the null hypothesis. The obtained *t* value was 1.39. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Right Thigh Circumference

To compare the initial mean score with the final mean score for the Right Thigh Circumference of the Isokinetic group, the *t* test for correlated samples was used. Table 40 presents the scores for the right thigh, the means, the differences between the means, standard deviation, and the *t* value.

Table 40. Comparison of Initial and Final Scores for Right Thigh Circumference of the Isokinetic Group

Right Thigh Scores	$\bar{X}$	Difference	S.D.	t
Initial	56.371	-0.824	3.117	2.23*
Final	55.547		2.899	

*Significant at the .05 level of confidence

The mean scores for the Right Thigh of the Isokinetic group were 56.371 for the initial and 55.547 for the final. The difference of -0.824 cm was significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 2.23. Therefore, the null hypothesis that the means were equal was rejected.

Left Thigh Circumference

To compare the initial mean score with the final mean score for the Left Thigh of the Isokinetic group, the t test for correlated samples was used. Table 41 presents the scores for the left thigh, the means, the differences between the means, standard deviation, and the t value.

Table 41. Comparison of Initial and Final Scores for Left Thigh Circumference of the Isokinetic Group

Left Thigh Scores	$\overline{X}$	Difference	S.D.	t
Initial	56.415	-0.760	3.074	1.90
Final	55.655		2.829	

The mean scores for the Left Thigh of the Isokinetic group were 56.415 for the initial and 55.655 for the final. The difference of -0.760 cm was not significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 1.90. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Triceps Skinfold

To compare the initial mean score with the final mean score for the Triceps Skinfold of the Isokinetic group, the t test for correlated samples was used. Table 42 presents the scores for the triceps skinfold, the means, the differences between the means, standard deviation, and the t value.

Table 42. Comparison of Initial and Final Scores for Triceps Skinfold Measurement of the Isokinetic Group

Triceps Skinfold	$\bar{X}$	Difference	S.D.	t
Initial	20.367	-0.577	3.889	1.23
Final	19.790		3.184	

The mean scores for the Triceps Skinfold of the Isokinetic group were 20.367 for the initial and 19.790 for the final. The difference of -0.577 mm was not significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 1.23. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Suprailiac Skinfold

To compare the initial mean score with the final mean score for the Suprailiac Skinfold of the Isokinetic group, the t test for correlated samples was used. Table 43 presents the scores for the suprailiac skinfold, the means, the differences between the means, standard deviation, and the t value.

Table 43. Comparison of Initial and Final Scores for Suprailiac Skinfold Measurement of the Isokinetic Group

Suprailiac Skinfold	$\overline{X}$	Difference	S.D.	*t*
Initial	13.366	0.289	3.529	0.68
Final	13.655		4.094	

The mean scores for the Suprailiac Skinfold of the Isokinetic group were 13.366 for the initial and 13.655 for the final. The difference of 0.289 mm was not significant at the .05 level of confidence.

With 14 degrees of freedom a *t* value of greater than 2.145 was necessary to reject the null hypothesis. The obtained *t* value was 0.68. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

<u>Percent of Fat</u>

To compare the initial mean score with the final mean score for the Percent of Fat of the Isokinetic group, the *t* test for correlated samples was used. Table 44 presents the scores for the fat percentage, the means, the differences between the means, standard deviation, and the *t* value.

Table 44. Comparison of Initial and Final Scores for Percent of Fat Measurement of the Isokinetic Group

Percent of Fat	$\overline{X}$	Difference	S.D.	t
Initial	21.967	-0.060	2.112	0.23
Final	21.907		2.029	

The mean scores for the Percent of Fat of the Isokinetic group were 21.967 for the initial and 21.907 for the final. The difference of -0.060% was not significant at the .05 level of confidence.

With 14 degrees of freedom a t value greater than 2.145 was necessary to reject the null hypothesis. The obtained t value was 0.23. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Summary of Data - Isokinetic Group

Table 45 presents the scores for anthropometric data, the means, the difference between the means, standard deviation, and the t values of the Isokinetic group.

Table 45. Summary Analyses of Data for Anthropometric Scores of the Isokinetic Group

Test Item	$\overline{X}$	Difference	S.D.	t
Weight				
Initial	64.281	0.635	6.509	1.37
Final	64.916		6.105	
Right Biceps				
Initial	26.489	0.551	1.456	2.87*
Final	27.040		1.386	
Left Biceps				
Initial	26.699	0.316	1.723	1.39
Final	27.015		1.443	
Right Thigh				
Initial	56.371	-0.824	3.117	2.23*
Final	55.547		2.899	
Left Thigh				
Initial	56.415	-0.760	3.074	1.90
Final	55.655		2.829	
Triceps Skinfold				
Initial	20.367	-0.577	3.889	1.23
Final	19.790		3.184	
Suprailiac Skinfold				
Initial	13.366	0.289	3.529	0.68
Final	13.655		4.094	
Percent of Fat				
Initial	21.967	-0.060	2.112	0.23
Final	21.907		2.029	

*Significant at the .05 level of confidence

The test items of Weight, Right Biceps Circumference, Left Biceps Circumference, and Suprailiac Skinfold showed an increase from Initial to Final measurement; whereas Right Thigh Circumference, Left Thigh Circumference, Triceps Skinfold, and Percent of Fat showed a decrease in measurement.

The obtained _t_ value was less than 2.145 (14 degrees of freedom) for the test items of Weight, Left Biceps Circumference, Left Thigh Circumference, Triceps Skinfold, Suprailiac Skinfold, and Percent of Fat. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal. The obtained _t_ value was greater than 2.145 for the test items of Right Biceps Circumference and Right Thigh Circumference. Therefore, the null hypothesis that the means were equal was rejected. The rejection of the null hypothesis indicated that a significant difference was established between the Initial and Final scores. The anthropometric test item of Right Biceps Circumference showed a significant increase from Initial to Final measurement; whereas Right Thigh Circumference showed a significant decrease in measurement for the Isokinetic group.

Analysis of Mean Improvement Scores (Final - Initial) of Anthropometric Data for the Isotonic Group Versus the Isokinetic Group

Weight

To compare the mean improvement score for Weight of the Isotonic group with the mean improvement score for Weight of the Isokinetic group, the *t* test for independent samples was used. Table 46 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the *t* value.

Table 46. Comparison of Mean Improvement Scores for Weight of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	*t*
Isotonic	0.655	0.020	0.810	0.04
Isokinetic	0.635		1.797	

The mean improvement scores for Weight were 0.655 for the Isotonic group and 0.635 for the Isokinetic group. The difference of 0.020 kg was not significant at the .05 level of confidence.

With 27 degrees of freedom a *t* value greater than 2.052 was necessary to reject the null hypothesis. The obtained *t* value was 0.04. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Right Biceps Circumference

To compare the mean improvement score for the Right Biceps of the Isotonic group with the mean improvement score for the Right Biceps of the Isokinetic group, the t test for independent samples was used. Table 47 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 47. Comparison of Mean Improvement Scores for Right Biceps Circumference of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	0.746	0.195	0.523	0.81
Isokinetic	0.551		0.742	

The mean improvement scores for Right Biceps were 0.746 for the Isotonic group and 0.551 for the Isokinetic group. The difference of 0.195 cm was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 0.81. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Left Biceps Circumference

To compare the mean improvement score of the Isotonic group with the mean improvement score of the Isokinetic group for Left Biceps Circumference, the t test for independent samples was used. Table 48 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 48. Comparison of Mean Improvement Scores for Left Biceps Circumference of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	0.631	0.315	0.632	1.10
Isokinetic	0.316		0.878	

The mean improvement scores for Left Biceps were 0.631 for the Isotonic group and 0.316 for the Isokinetic group. The difference of 0.315 cm was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 1.10. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Right Thigh Circumference

To compare the mean improvement score of the Isotonic group with the mean improvement score of the Isokinetic group for Right Thigh Circumference, the t test for independent samples was used. Table 49 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 49. Comparison of Mean Improvement Scores for Right Thigh Circumference of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	-0.500	0.324	1.102	0.68
Isokinetic	-0.824		1.430	

The mean improvement scores for Right Thigh were -0.500 for the Isotonic group and -0.824 for the Isokinetic group. The difference of 0.324 cm was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 0.68. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Left Thigh Circumference

To compare the mean improvement score of the Isotonic group with the mean improvement score of the Isokinetic group for Left Thigh Circumference, the t test for independent samples was used. Table 50 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the *t* value.

Table 50. Comparison of Mean Improvement Scores for Left Thigh Circumference of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	*t*
Isotonic	-0.529	0.231	1.419	0.42
Isokinetic	-0.760		1.551	

The mean improvement scores for Left Thigh Circumference were -0.529 for the Isotonic group and -0.760 for the Isokinetic group. The difference of 0.231 cm was not significant at the .05 level of confidence.

With 27 degrees of freedom a *t* value greater than 2.052 was necessary to reject the null hypothesis. The obtained *t* value was 0.42. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Triceps Skinfold

To compare the mean improvement score of the Isotonic group with the mean improvement score of the Isokinetic group for Triceps Skinfold, the *t* test for independent samples was used. Table 51 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 51. Comparison of Mean Improvement Scores for Triceps Skinfold Measurement of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	-0.476	0.101	1.306	0.17
Isokinetic	-0.577		1.821	

The mean improvement scores for Triceps Skinfold were -0.476 for the Isotonic group and -0.577 for the Isokinetic group. The difference of 0.101 mm was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 0.17. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Suprailiac Skinfold

To compare the mean improvement score of the Isotonic group with the mean improvement score of the Isokinetic group for Suprailiac Skinfold, the t test for independent samples was used. Table 52 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 52. Comparison of Mean Improvement Scores for Suprailiac Skinfold Measurement of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	-0.095	0.384	1.811	0.60
Isokinetic	0.289		1.650	

The mean improvement scores for Suprailiac Skinfold were -0.095 for the Isotonic group and 0.289 for the Isokinetic group. The difference of 0.384 mm was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 0.60. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Percent of Fat

To compare the mean improvement score of the Isotonic group with the mean improvement score of the Isokinetic group for Percent of Fat, the t test for independent samples was used. Table 53 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t value.

Table 53. Comparison of Mean Improvement Scores for Percent of Fat of the Isotonic Group and the Isokinetic Group

Group	Mean Improvement Scores	Improvement Mean Difference	S.D.	t
Isotonic	-0.200	0.140	0.802	0.41
Isokinetic	-0.060		1.017	

The mean improvement scores for Fat Percentage were -0.200 for the Isotonic group and -0.060 for the Isokinetic group. The difference of 0.140% was not significant at the .05 level of confidence.

With 27 degrees of freedom a t value greater than 2.052 was necessary to reject the null hypothesis. The obtained t value was 0.41. Therefore, no evidence was provided that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

Summary of Data - Isotonic Group and Isokinetic Group

Table 54 presents the groups, the mean improvement scores, standard deviation, difference between improvement means, and the t values for all anthropometric test items of the two groups.

Table 54. Summary Analyses of Data for Anthropometric Test Items

Test Item	Mean Improvement Scores	S.D.	Improvement Mean Difference	t
Weight				
Isotonic Group	0.655	0.810	0.020	0.04
Isokinetic Group	0.635	1.797		
Right Biceps				
Isotonic Group	0.746	0.523	0.195	0.81
Isokinetic Group	0.551	0.742		
Left Biceps				
Isotonic Group	0.631	0.632	0.315	1.10
Isokinetic Group	0.316	0.878		
Right Thigh				
Isotonic Group	-0.500	1.102	0.324	0.68
Isokinetic Group	-0.824	1.430		
Left Thigh				
Isotonic Group	-0.529	1.419	0.231	0.42
Isokinetic Group	-0.760	1.551		
Triceps Skinfold				
Isotonic Group	-0.476	1.306	0.101	0.17
Isokinetic Group	-0.577	1.821		
Suprailiac Skinfold				
Isotonic Group	-0.095	1.811	0.384	0.60
Isokinetic Group	0.289	1.650		
Percent of Fat				
Isotonic Group	-0.200	0.802	0.140	0.41
Isokinetic Group	-0.060	1.017		

The obtained t value was less than 2.052 (27 degrees of freedom) for all test items, including Weight, Circumference of the Right Biceps and the Left Biceps, Circumference of the Right Thigh and the Left Thigh, Triceps Skinfold, Suprailiac Skinfold, and Percent of Body Fat. Therefore, no evidence was provided for any test item that would warrant the rejection of the null hypothesis that the means of the two groups were equal.

CHAPTER V

DISCUSSION OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER RESEARCH

This chapter includes a discussion of the study in three sections: (1) findings, (2) conclusions, and (3) recommendations for further study.

Discussion of Findings

The purpose of this study was to determine whether isotonic or isokinetic exercise was superior for strength development in female subjects. Anthropometric measurements were used to assess changes in body proportions, especially changes in limb girths due to muscle hypertrophy.

The results of the study showed no evidence that one group was superior to the other in general strength gain attributable to participation in the eight-week training program. There were significant increases in strength development within each group, and significant differences existed between the two groups in some of the strength test items.

The results of the *t* test for correlated samples showed significant increases in all strength test items of both groups. These significant increases indicated that each type of resistance program developed strength in the areas of training.

The varied results of the t test for independent samples for comparing the two programs, did not substantiate the superiority of general strength development with one program. In the analysis of arm extension, there was no significant difference in strength improvement between the two groups. In the analysis of arm flexion, the t test revealed a significant difference in favor of the Isokinetic group. The F test for homogeneity of variance indicated that the variances of the two groups were not equal. Therefore, it was not possible to evaluate the significance of the mean difference of the samples. In the analysis of leg extension, the t test revealed a significant difference in favor of the Isotonic group. The F test for homogeneity of variance upheld the validity of the t test, substantiating the assumption that the groups were taken from the same population. In the analysis of leg flexion, there was no significant difference in strength improvement between the two groups.

The analysis of anthropometric measurements revealed a general trend toward a gain in weight with a related loss of fat, and a change in body dimensions. The decrease of the lower limb girths and the concurrent increase of the upper limb girths enhanced body proportions. The correlated _t_ test showed a significant increase in the weight of the Isotonic group. The weight of the Isokinetic group increased, although the difference was not significant. The independent _t_ test revealed that there was no significant difference in the weight change between the two groups.

The circumference of the right and left biceps increased with training for both groups. The correlated _t_ test indicated that the increase was significant for both the right and left biceps of the Isotonic group and for the right biceps of the Isokinetic group. The increase was not significant for the left biceps of the Isokinetic group. The independent _t_ test showed no significant difference between the two groups for biceps measurement.

The circumference of the right and left thigh of both groups decreased from pre-training to post-training. The only decrease deemed significant by the correlated _t_ test was for the right thigh circumference of the Isokinetic group. The independent _t_ test revealed no significant difference in thigh circumference between the two groups.

The measurement of the triceps skinfold and the suprailiac skinfold, as indicators of site-specific adipose tissue, were used in the calculation of percent of body fat. The triceps skinfold decreased for both groups, but the decrease was not significant. The supra-iliac skinfold decreased for the Isotonic group and increased for the Isokinetic group, but neither change was significant. The independent t test revealed no significant difference in the skinfold values for either group. The percent of fat calculation decreased for both groups, but no significant difference was established by the correlated t test. The independent t test showed no significant difference between groups for percent of fat.

Summary of Findings

1) There was a significant increase found in arm extension of both the Isotonic group and the Isokinetic group; there was no significant difference between the two groups.

2) There was a significant increase found in arm flexion of both groups, and there was a significant improvement of the Isokinetic group over the Isotonic group. It was not possible to evaluate the significance because the variances were not equal.

3) There was a significant increase in leg extension of both groups. There was a significant difference of the improvement of the Isotonic group over the Isokinetic group in leg extension, which was validated by the test for homogeneity of variance.

4) There was a significant increase found in leg flexion of both the Isotonic group and the Isokinetic group; there was no significant difference between the two groups.

5) There was a significant increase in weight of the Isotonic group, but the increase of the Isokinetic group was not significant. There was no significant difference between the two groups.

6) There was a significant increase in right biceps

circumference of both groups, but no significant difference between the two groups.

7) There was a significant increase in left biceps circumference of the Isotonic group, but the increase was not significant for the Isokinetic group. No significant difference existed between the two groups.

8) The decrease in right thigh circumference of the Isotonic group was not significant, but the Isokinetic group did show a significant decrease. No significant difference was found between the two groups.

9) The decrease in left thigh circumference was not significant for either group; no significant difference existed between the two groups.

10) The measurement of triceps skinfold showed a decrease which was not significant for either group, and no significant difference was found between the groups.

11) The measurement of suprailiac skinfold showed a decrease which was not significant for either group. No significant difference existed between groups.

12) The decrease in calculation of fat percentage was not significant for either group, and no significant difference was found between groups.

Conclusions

The conclusions, based on the findings of the study, indicate:

1) Both an Isotonic and an Isokinetic program of resistance training are effective for strength development in females.

2) One training program is not superior to the other for general strength development in females. Isotonic resistance training is superior to Isokinetic resistance training in the development of the strength of leg extension. The large apparent increases in strength which occurred during the first few weeks of the study, may have resulted from the underestimation of quadriceps strength in determining the initial six RM value.

3) The increase in total body weight with a concomitant decrease in relative body fat indicates an increase in muscle hypertrophy.

4) Muscle hypertrophy is evident in significantly increased girths of the upper arms.

5) The decrease in lower limb girths may be a result of hypertrophy of muscle fibers with a corresponding decrease in surrounding fat tissue.

The conclusions reached in this study substantiate previous studies of strength development in females by isotonic resistance methods. The study by Wilmore (61) showed a thirty to fifty percent improvement in strength resulting from a ten-week program. Mayhew and Gross (32) assessed strength gain by measuring performance in several of the exercises utilized during training. They showed significant increases in strength measurements of the leg press, bench press and arm curls.

The results of comparative studies involving females using isotonic and isokinetic methods of training are limited. The study by Pipes and Wilmore (41) evaluated relative strength gains in male subjects. The authors concluded that "the results demonstrated a clear superiority of the isokinetic training procedures over the isotonic procedures relative to strength, anthropometric measures and motor performance tasks." The conclusions derived from this study infer a contradiction of the conclusions obtained by Pipes and Wilmore.

The conclusions dealing with changes in body composition as a result of engaging in a program of resistance training, substantiate some aspects of previous studies and refute other aspects. The study by Mayhew and Gross (32) found no significant increase in total body weight for their female subjects. Lean body weight increased significantly with a corresponding significant decrease in relative fat. A significant increase in biceps circumference was observed, but no change in thigh circumference was noted by the authors. Skinfold measurements showed insignificant reductions as a result of training.

Recommendations for Further Study

The amount of research in the area of resistance training for females has been extremely limited. Isotonic training methods have been the basis for most female research. Comparative studies of Isotonic and Isokinetic exercise generally have been conducted with males. Therefore, there is a need for further research on females.

Isotonic exercise, performed on the Universal Variable Resistance Machine, offered a distinct disadvantage to the female subject. Most of the stations were designed for males, with their relatively longer limbs. The hamstrings station (leg flexion) was exceptionally difficult and discouraged full flexion of the legs. Studies using a resistance machine with adjustable positions of the lever arm might enhance strength training for "non-average" individuals.

The success of isokinetic exercise is based on the motivation of the subject. The repetition of maximal performance bouts requires a desire for strength improvement. When used as a method of injury rehabilitation, isokinetic exercise depends on continual encouragement during performance. Studies comparing motivational aspects of resistance training might provide insight into relative strength gains with different programs.

This study was conducted with the assessment of strength determined by a method specific to the training program. A group trained with one type of exercise may achieve a significant gain that is due to the specificity of the testing procedure. Assessment by a specifically designed program of athletic performance could yield different results. The combination of program-specific testing and general athletic ability testing might prove valuable for insight into strength training modes, especially as an indicator in performance.

An eight-week program of resistance training was recognized by previous investigators to result in strength increases. The length of the study may have negatively influenced significant differences in strength gains between the two programs of training. A study lasting ten weeks or longer may provide a better evaluation of the superiority of one regime.

The design of the training program may have influenced results. The choice of six repetitions, performed in sets of three was based on data gathered by other investigators. The design of an "optimal" training program may provide significantly different results between the two groups.

Finally, the measurement of anthropometric dimensions may be improved. Skinfold determinations are not extremely reliable. Hydrostatic weighing provides a more accurate measure of body density to be used in the calculation of body fat percentage. The amount of time involved in obtaining density measures by hydrostatic weighing could be a limiting factor for its use.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Alarotu, A., "A Comparison of Selected Nautilus System and Freebar Exercises on Strength." Unpublished Master's Thesis, Brigham Young University, Provo, Utah, August 1976. Pp. vii + 54.

2. Allsen, P. et al., Fitness for Life. Dubuque, Iowa: Wm. C. Brown Co., 1976. Pp. 109-123.

3. Ariel, G., "Variable Resistance Exercise: A Biomechanical Approach to Muscular Training." Universal Fitness Laboratory Technical Report Uni-3, January 1974.

4. Barney, V. and Bangerter, B., "Comparison of Three Programs of Progressive Resistance Exercise." Research Quarterly, XXXII (May 1961), 138-146.

5. Berger, R., "Effect of Varied Weight Training Programs on Strength." Research Quarterly, XXXIII (May 1962), 168-181.

6. Capen, E. E., "Study of Four Programs of Heavy Resistance Exercises for Development of Muscular Strength." Research Quarterly, XXVII (May 1956), 132-142.

7. Caporal, M., "A Comparison of Various Methods for Developing Strength in Arm and Shoulder Muscles of College Women." Unpublished Master's Thesis, University of Illinois, Urbana, Illinois, 1963. Pp. 42.

8. Clarke, D., "Adaptations in Strength and Muscular Endurance Resulting from Exercise." Wilmore, J. (ed.), Exercise and Sports Sciences Reviews. New York: Academic Press, Vol. I, 1973. Pp. 73-102.

9. Clarke, D. and Henry, F., "Neuromotor Specificity and Increased Speed from Strength Development." Research Quarterly, XXXII (October 1961), 315-325.

10. Clarke, D. and E. Herman, "Objective Determination of Resistance Load for Ten Repetitions Maximum for Quadriceps Development." Research Quarterly, XXVI (December 1955), 385-390.

11. Clarke, H. H., Muscular Strength and Endurance in Man. New Jersey: Prentice Hall, Inc., 1966. 204 pp.

12. Consolazio, C. F. et al., Physiological Measurements of Metabolic Functions in Man. New York: McGraw-Hill Co., 1963. Pp. 255-312.

13. Darden, E., "Frequently Asked Questions About Muscle, Fat, and Exercise." Athletic Journal, LVI (November 1975), 85-89.

14. Dotson, C. O. and Kirkendall, D. R., Statistics for Physical Education, Health, and Recreation. New York: Harper and Row, 1974. 308 pp.

15. Drinkwater, B., "Physiological Responses of Women to Exercise." Wilmore, J. (ed.), Exercise and Sports Sciences Reviews, Vol. I. New York: Academic Press, 1973. Pp. 125-153.

16. Hellebrandt, F. A. and Houtz, S., "Mechanisms of Muscle Training in Man: Experimental Demonstrations of the Overload Principle." Physical Therapy Review, XXXVI (1956), 371-383.

17. Hellebrandt, F. A. and Houtz, S., "Methods of Muscle Training: The Influence of Pacing." Physical Therapy Review, XXXVIII (1958), 319-326.

18. Hettinger, T., Physiology of Strength. Springfield: C. C. Thomas, 1961. Pp. V and 9-44.

19. Hinson, M. and Rosentswieg, J., "Comparative Electromyographic Values of Isometric, Isotonic, and Isokinetic Contraction." Research Quarterly, XLIV (March 1973), 71-78.

20. Hislop, H. and Perrine, J., "The Isokinetic Concept of Exercise." Physical Therapy, XLVII (February 1967), 114-117.

21. Hunsicker, P. and Donnelly, R. J., "Instruments to Measure Strength." Research Quarterly, XXVI (December 1955), 408-420.

22. Hunsicker, P. and Greey, G., "Studies in Human Strength." Research Quarterly, XXVIII (May 1957), 109-122.

23. Jackson, A. S. and Frankiewicz, R., "Factorial Expressions of Muscular Strength." Research Quarterly, XLVI (May 1975), 206-217.

24. Johnson, J. and Siegel, D., "Reliability of an Isokinetic Movement of the Knee Extensors." Research Quarterly, XLIX (March 1978), 88-90.

25. Jones, A., "High Intensity Strength Training for All Sports." Pamphlet published by Nautilus Midwest, University Plaza, Cincinnati, Ohio, 1974.

26 Lamphiear, D. E. and Montoye, H. J., "Muscular Strength and Body Size." Human Biology, XLVIII (1976), 147-160.

27. Laubach, L. L. and McConville, J. T., "Muscle Strength, Flexibility and Body Size of Adult Males." Research Quarterly, XXXVII (October 1966), 384-392.

28. Lumex, "Orthotron Operating and Positioning Handbook." Pamphlet published by Lumex, Inc., Bay Shore, New York, 1973.

29. McCloy, C. H., "Endurance." Physical Educator, V (March 1948), 9.10, and 23.

30. Malina, R. M., "Anthropometric Correlates of Strength and Motor Performance." Wilmore, J. and Keogh, J. (ed.), Exercise and Sport Science Reviews, Vol. III. New York: Academic Press, 1975. Pp. 249-274.

31. Mathews, D. and Fox, E. L., The Physiological Basis of Physical Education and Athletics. Philadelphia: W. B. Saunders Co., 1976. 542 pp.

32. Mayhew, J. L. and Gross, P. M., "Body Composition Changes in Young Women with High Resistance Weight Training." Research Quarterly, XLV (December 1974), 433-440.

33. Moffroid, M. et al., "A Study of Isokinetic Exercise." Physical Therapy, XLIX (1969), 735-746.

34. Moffroid, M. and Kusiak, E., "The Power Struggle: Definition and Evaluation of Power of Muscular Performance." Physical Therapy, LV (1975), 1098-1104.

35. Montoye, H. and Lamphiear, D., "Grip and Arm Strength in Males and Females, Age 10 to 69." Research Quarterly, XLVIII (March 1977), 109-120.

36. Morris, A., "Effects of Fatiguing Isometric and Isotonic Exercise on Fractionated Patellar Tendon Reflex Components." Research Quarterly, XLVIII (March 1977), 121-128.

37. Osternig, L., "Optimal Isokinetic Loads and Velocities Producing Muscular Power in Human Subjects." Archives of Physical Medicine and Rehabilitation, LVI (1975), 152-155.

38. Osternig, L. et al., "Isokinetic and Isometric Torque Force Relationships." Archives of Physical Medicine and Rehabilitation, LVII (1977), 254-257.

39. Perrine, J., "Isokinetic Exercise and the Mechanical Energy Potentials of Muscle." Journal of Health, Physical Education and Recreation, XXXIX (May 1968), 40-44.

40. Peterson, J., "Total Conditioning: A Case Study." Athletic Journal, LVI (September 1975), 40-55.

41. Pipes, T. and Wilmore, J., "Isokinetic Versus Isotonic Strength Training in Adult Men." Medicine and Science in Sports, VII (1975), 262-274.

42. Pipes, T. and Wilmore, J., "Muscular Strength Through Isotonic and Isokinetic Resistance Training." Athletic Journal, LVI (June 1976), 42-45.

43. Rasch, P. and Pierson, W., "Some Relationships of Isometric Strength, Isotonic Strength and Anthropometric Measures." Ergonomics, VI (1963), 211-215.

44. Roberts, D. F. et al., "Arm Strength and Body Dimensions." Human Biology, XXXI (1959), 334-343.

45. Rosentswieg, J. et al., "An Electromyographic Comparison of an Isokinetic Bench Press Performed at Three Speeds." Research Quarterly, XLVI (December 1975), 471-475.

46. Ryan, A., "The Concept of Physical Fitness." Ryan, Allan and Allman, F. Jr. (ed.), Sports Medicine. New York: Academic Press, 1974. Pp. 31-55.

47. Shambes, G. M., "The Comparative Effects of Isotonic and Isometric Muscular Contractions on the Development of Strength in the Quadriceps Muscle." Unpublished Master's Thesis, Smith College, Northhampton, Mass., June 1958. Pp. 57.

48. Shaver, L. G., Experiments in Physiology of Exercise. Minneapolis: Burgess Publishing Co., 1973. Pp. 15-20 and 75-80.

49. Sloan, A. W. and Weir, J. B. de V., "Nomograms for Prediction of Body Density and Total Body Fat from Skinfold Measurements." Journal of Applied Physiology, XXVIII (February 1970), 221-222.

50. Steinhaus, A., "Chronic Effects of Exercise." Physiological Reviews, XIII (1933), 103-147.

51. Stephens, M., "A Study of the Effects of Isotonic and Isometric Exercise on Selected Physiological Variables." Unpublished Master's Thesis, University of North Carolina, Greensboro, North Carolina, June 1965.

52. Sylvester, P., "The Effects of Two Different Exercise Programs on College Women as Measured by Girth and Skinfold Thickness." Unpublished Master's Thesis, University of North Carolina, Greensboro, North Carolina, August 1967.

53. Thistle, H. et al., "Isokinetic Contraction: A New Concept of Resistive Exercise." Archives of Physical Medicine and Rehabilitation, XLVIII (1967), 279-282.

54. Thomas, C., "Special Problems of the Female Athlete." Ryan, Allan and Allman, F. Jr. (ed.), Sports Medicine. New York: Academic Press, 1974. Pp. 347-373.

55. Thorstensson, A. and Karlson, J., "Fatiguability and Fiber Composition of Human Skeletal Muscle." Acta physiol scand, XCVIII (1976), 318-322.

56. Thorstensson, A. et al., "Force Velocity Relations and Fiber Composition in Human Knee Extensor Muscles." Journal of Applied Physiology, XL (1976), 12-15.

57. Ulrich, C., "Women and Sport." Johnson, Warren (ed.), Science and Medicine of Exercise and Sports. New York: Harper and Brothers Co., 1960. Pp. 508-516.

58. Weber, J. E. and Lamb, D. R., Statistics and Research in Physical Education. St. Louis: C. V. Mosby Co., 1970. Pp. 233.

59. Wilkie, D. R., "The Relation Between Force and Velocity in Human Muscle." Journal of Physiology, CX (1950), 249-280.

60. Williams, M. and Stutzman, L., "Strength Variation Through the Range of Joint Motion." Physical Therapy Review, XXXIX (1959), 145-152.

61. Wilmore, J., "The Female Athlete." Journal of School Health, XLVII (1977), 227-233.

62. Wilmore, J. and Behnke, A., "An Anthropometric Estimation of Body Density and Lean Body Weight in Young Women." American Journal of Clinical Nutrition, XXIII (1970), 267-274.

APPENDIX A

PARTICIPATION AGREEMENT FORM

I, ______________________________

agree to participate in the research study concerning isotonic versus isokinetic exercise, conducted by Diane L. Gillo at Western Michigan University during Winter semester of 1979. I realize that the study involves resistance training for a period of 8 weeks, and I agree to participate in either group for strength training, 3 alternate days per week. I realize that it is important to complete the program in order to provide accurate results for statistical analysis, and therefore will complete the 8 week program and be available for measurements following training.

Signed ______________________

Dated ____________

APPENDIX B

TEST ITEM SCORE CARD

NAME ______________________________ MAJOR ________________________

AGE ____ PHONE # __________ SECTION ______ ______________ EXERCISE

INITIAL	MEASUREMENTS	FINAL
________	Arm Strength	________
________	Leg Strength	________
________	Height	________
________	Weight	________
________	Bust	________
________	Waist	________
________	Hips	________
________	Biceps	________
________	Thigh	________
________	Triceps Skinfold	________
________	Suprailiac Skinfold	________
________	Body Density	________
________	% Fat	________

DATE	R.ARM	L.ARM	R.LEG	L.LEG		DATE	R.ARM	L.ARM	R.LEG	L.LEG

APPENDIX C

TEST ITEM RAW SCORES

Pre-Training Raw Strength Scores of the Isotonic Group

Subject Number	Arm Extension	Arm Flexion	Leg Extension	Leg Flexion
7	85	40	50	40
8	90	35	25	20
9	65	25	35	30
12	70	30	50	30
13	65	35	35	20
14	75	20	30	30
17	70	30	50	20
18	65	30	50	20
19	65	20	50	30
29	85	40	80	50
30	65	20	40	25
31	65	30	35	20
33	80	40	30	30
34	65	25	25	25

Post-Training Raw Strength Scores of the Isotonic Group

Subject Number	Arm Extension	Arm Flexion	Leg Extension	Leg Flexion
7	115	55	130	55
8	95	50	100	50
9	80	35	80	45
12	75	40	110	50
13	100	45	100	45
14	95	40	70	40
17	85	45	100	50
18	95	50	90	45
19	85	45	130	55
29	105	55	140	60
30	80	40	90	50
31	95	50	95	35
33	105	50	110	45
34	85	35	85	45

Pre-Training Raw Strength Scores of the Isokinetic Group

Subject Number	Arm Extension		Arm Flexion		Leg Extension		Leg Flexion	
	R	L	R	L	R	L	R	L
1	11	16	31	34	150	143	102	105
2	9	3	35	25	112	108	98	89
3	3	1	16	20	92	110	72	68
4	12	10	17	16	130	140	115	100
5	12	4	25	32	112	92	100	98
6	15	16	30	20	157	151	134	96
10	3	8	31	19	100	107	83	85
20	12	9	30	14	150	125	106	108
21	15	17	20	16	132	122	88	85
22	1	1	20	24	105	105	90	95
23	20	12	52	31	150	177	136	142
24	1	1	19	24	108	115	84	80
25	19	16	36	37	110	100	113	116
27	4	7	32	30	120	130	106	93
28	6	7	42	30	95	122	88	100

Post-Training Raw Strength Scores of the Isokinetic Group

Subject Number	Arm Extension R	Arm Extension L	Arm Flexion R	Arm Flexion L	Leg Extension R	Leg Extension L	Leg Flexion R	Leg Flexion L
1	33	33	50	50	187	206	130	135
2	28	23	77	60	116	137	126	130
3	28	23	50	50	175	124	125	120
4	28	43	75	90	150	130	95	110
5	28	33	65	60	135	135	100	80
6	38	38	62	70	200	185	140	125
10	43	38	60	65	137	145	105	120
20	33	28	40	55	138	145	120	126
21	18	28	35	40	160	186	134	135
22	13	13	40	30	136	157	110	112
23	48	43	85	85	220	200	158	140
24	18	18	40	50	150	145	105	103
25	33	38	55	60	165	200	135	135
27	38	48	60	60	170	173	137	140
28	38	38	55	50	144	193	140	150

Initial Raw Anthropometric Scores of the Isotonic Group

Subject Number	Height	Weight	Biceps R	Biceps L	Thigh R	Thigh L	Triceps Skinfold	Suprailiac Skinfold	Percent of Fat
7	165.74	63.73	27.00	27.00	57.48	57.48	17.17	11.33	20.2
8	174.63	60.56	26.04	25.40	51.44	51.44	17.83	12.00	20.6
9	158.75	50.12	24.13	24.13	51.77	50.50	18.17	13.50	21.5
12	172.09	57.61	25.10	25.10	51.44	52.07	16.50	12.33	20.2
13	156.85	55.34	25.10	24.77	54.31	54.61	19.50	17.83	23.1
14	163.83	55.23	23.19	22.56	49.86	49.23	17.17	12.00	20.2
17	170.82	65.77	26.04	26.67	57.15	57.79	22.00	20.50	25.2
18	160.66	62.94	28.91	29.21	55.25	53.34	24.83	18.50	25.6
19	172.72	63.05	24.46	24.46	56.52	57.15	16.83	11.17	19.8
29	165.10	60.33	27.31	27.00	54.61	53.98	18.33	12.67	21.0
30	167.01	56.69	23.83	23.83	51.77	51.44	12.67	11.50	18.6
31	160.02	53.98	26.04	24.77	53.34	52.40	23.67	14.67	23.5
33	157.48	61.46	28.91	29.21	57.15	56.52	28.83	21.33	27.8
34	163.20	63.39	26.67	26.04	57.48	58.85	24.17	13.50	23.5

Final Raw Anthropometric Scores of the Isotonic Group

Subject Number	Weight	Biceps R	Biceps L	Thigh R	Thigh L	Triceps Skinfold	Suprailiac Skinfold	Percent of Fat
7	65.09	28.58	27.94	58.42	57.79	17.00	10.67	19.8
8	61.46	26.67	25.40	50.80	50.80	18.17	14.17	21.5
9	49.90	24.77	24.77	52.40	51.44	17.83	13.33	21.0
12	58.51	24.77	24.77	52.07	52.71	15.50	11.33	19.4
13	55.11	26.67	25.40	52.71	53.67	17.17	16.67	21.9
14	56.02	23.83	24.13	49.23	49.23	14.00	13.33	19.8
17	66.68	27.00	27.00	57.15	56.85	22.33	15.33	23.5
18	63.50	29.21	29.21	53.98	52.71	24.83	18.00	25.2
19	62.14	24.77	24.77	53.34	52.71	15.50	12.67	20.2
29	60.10	27.64	27.31	53.67	52.71	16.83	12.00	20.2
30	58.29	25.10	24.77	52.07	52.71	12.67	11.67	18.6
31	55.11	26.67	25.10	52.40	51.44	23.50	16.33	23.9
33	62.03	29.85	30.48	57.15	57.15	29.50	22.33	28.6
34	65.43	27.64	27.94	57.48	57.48	26.17	13.67	24.4

Initial Raw Anthropometric Scores of the Isokinetic Group

Subject Number	Height	Weight	Biceps R	Biceps L	Thigh R	Thigh L	Triceps Skinfold	Suprailiac Skinfold	Percent of Fat
1	160.66	63.84	28.27	28.91	57.79	58.12	25.50	17.00	25.2
2	168.91	64.86	26.67	26.37	59.06	60.33	23.33	13.50	23.1
3	165.10	60.55	26.37	26.67	58.12	57.15	26.83	9.00	22.7
4	180.98	73.26	27.94	29.21	60.96	59.69	18.67	18.00	23.1
5	164.47	50.80	24.46	24.13	48.90	49.53	20.17	9.83	20.6
6	172.72	68.04	27.00	27.00	57.79	57.79	22.67	12.00	22.3
10	168.91	67.25	27.31	27.64	58.42	57.15	20.33	18.17	23.5
20	171.45	64.18	28.58	28.91	54.61	54.31	22.50	14.00	23.1
21	168.91	65.54	26.67	26.67	55.25	55.58	17.67	11.50	20.2
22	161.93	54.88	25.10	24.13	55.88	57.15	17.83	12.33	20.6
23	184.79	76.43	27.64	27.94	56.52	56.21	19.00	10.83	20.6
24	169.55	69.63	27.00	27.31	60.33	61.29	24.00	20.67	25.6
25	174.63	61.23	23.83	24.13	53.98	53.34	12.17	9.50	17.7
27	172.72	60.10	24.46	25.10	52.71	52.71	19.50	12.33	21.4
28	166.37	63.62	26.04	26.37	55.25	55.88	15.33	11.83	19.8

Final Raw Anthropometric Scores of the Isokinetic Group

Subject Number	Weight	Biceps		Thigh		Triceps Skinfold	Suprailiac Skinfold	Percent of Fat
		R	L	R	L			
1	61.46	27.64	27.94	55.88	56.52	23.17	17.33	24.4
2	66.90	28.27	27.31	59.39	60.33	20.67	15.00	22.7
3	61.46	27.94	28.27	56.52	55.88	26.17	11.00	23.5
4	74.84	27.64	27.94	60.96	60.33	17.33	19.00	22.7
5	51.71	24.77	25.40	48.90	49.23	19.00	10.17	20.6
6	68.72	27.00	26.67	57.79	57.15	22.33	10.00	21.5
10	68.95	27.64	27.94	57.48	56.85	20.83	21.00	24.8
20	62.60	28.91	28.91	52.71	52.07	19.17	10.00	20.6
21	68.49	28.27	28.27	55.88	55.58	20.17	12.50	21.5
22	56.47	24.77	24.46	53.98	55.25	18.83	11.33	20.6
23	73.94	28.27	28.27	54.94	55.58	16.17	10.67	19.4
24	67.81	27.31	26.67	55.88	56.52	22.17	21.50	25.6
25	63.73	25.40	24.77	55.25	55.58	13.50	10.33	18.6
27	61.80	25.10	25.10	52.71	52.71	21.17	12.50	21.9
28	64.86	26.67	27.31	54.94	55.25	16.17	12.50	20.2

APPENDIX D

CALCULATION SHEET FOR COMPUTATION OF PERCENT OF BODY FAT

NAME ______________________

DATE OF INITIAL MEASUREMENT __________

TRICEPS SKINFOLD __________ AVERAGE __________

SUPRAILIAC SKINFOLD __________ AVERAGE __________

$$D_B = 1.0764 - \left[0.00081 \times \text{Suprailiac Skinfold}\right] - \left[0.00088 \times \text{Triceps Skinfold}\right]$$

D_B = Body density

$$D_B = 1.0764 - 0.00081 (\quad) - 0.00088 (\quad)$$

$$\text{Percent of Fat} = \left[\frac{4.570}{D_B} - 4.142\right] \times 100$$

$$\% \text{ Fat} = \left[\frac{4.570}{\quad} - 4.142\right] \times 100$$

DATE OF FINAL MEASUREMENT __________

TRICEPS SKINFOLD __________ AVERAGE __________

SUPRAILIAC SKINFOLD __________ AVERAGE __________

$$D_B = 1.0764 - 0.00081 (\quad) - 0.00088 (\quad)$$

$$\% \text{ Fat} = \left[\frac{4.570}{\quad} - 4.142\right] \times 100$$

APPENDIX E

PARTICIPATION QUESTIONNAIRE

NAME ____________________ DATE __________

Were you dieting during the eight-week training program?

Yes _____ No _____

Did you start running during the eight-week training program?

Yes _____ No _____

Were you running regularly before you started the training program?

Yes _____ No _____

List any athletic activities engaged in during the training period, and approximate date you started.

Did you experience any injuries during the eight-week period which may have affected the results of the study?