THE EFFECTS OF A PROGRAM OF PROGRESSIVE RESISTANCE EXERCISE ON STRENGTH, MUSCLE GIRTH, AND BODY COMPOSITION OF COLLEGE WOMEN

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CHAPTER I

INTRODUCTION

At the present time in physical education and athletics, there is increasing emphasis being placed on vigorous and competitive sports programs for women. If women intend to reach their maximum physical potential in a competitive setting then efforts to develop optimal strength, speed, and endurance must also be increased.

The development and maintenance of strength through the use of heavy resistance weight training was a very controversial issue among physical educators and coaches for many years. This was due to the belief that it would produce bulky musculature limiting speed, flexibility and agility in movement. Thus, the use of heavy resistance weight training was not considered an acceptable method of developing strength in men, much less any form of weight training for women. However, in the late 1940's, Thomas DeLorme began to scientifically explore the area of strength development by application of the overload principle through heavy resistance exercises.

Since that time, numerous studies have been conducted on many physiological aspects of resistance exercise, which have resulted in some accepted principles concerning efficient methods of strength development. Some of these studies provide insight as to how the body reacts to this type of exercise in terms of muscle growth or hypertrophy and alterations of body composition. However, the vast majority of these studies have focused on the male population and very few have studied the effects of progressive resistance exercise on the female. Clayton Thomas, in a recent publication entitled Sports Medicine, pointed out

> . . . the little interest investigators have in using women as subjects in studies of physical education. It is almost as if there were a cultural or professional taboo against designing a research study involving women. Until this condition is altered, we will continue to be penalized by lack of information concerning half of the human race (1, p. 370).

Carl E. Klafs and Daniel O. Arnheim, in Modern Principles of Athletic Training, state:

> The cultural conditions under which we have lived have insisted that there are distinct physiological and psychological differences between men and women that preclude the latter from participating in strenuous physical activity, particularly of a competitive nature (2, p. 142).

The American culture has had a profound influence on determining an effete role for women, centered around the vague concept of femininity. Contributing to this concept was the faulty logic that due to the distinct physiological and psychological differences, mentioned by Klafs and Arnheim, vigorous exercise is detrimental to the female's health and morals, and will tend to have a masculinizing effect on women.

In recent years, the early 1970's, the female began to receive attention in the area of exercise physiology. Studies have been conducted supporting the belief that socio-psychological differences that exist between male and female are the result of social factors or cultural conditions rather than the result of actual sex differences (2, p. 149). Evidence began to surface disputing the belief that heavy exercise, particularly weight training, will develop unsightly and bulky muscles in women and that such exercises have a tendency to develop masculinity (2, p. 149).

The fact that very real physiological differences between the sexes exist was thoroughly substantiated by Thomas E. Shaffer, M.D. and reported at a National Research Conference on Women and Sport at Pennsylvania State University in 1972 (3, pp. 321-330). Shaffer began to differentiate the sexes from the time of conception, and continued through childhood, adolescence, puberty, young adulthood and adulthood. He elaborated on the skeletal and muscular differences, differences in body composition, nutritional needs, cardiovascular efficiency, endocrinology, and physical performance. He also built a very strong case supporting the belief that the hormonal differences between males and females are responsible for the differences in muscle growth as well as many of the other noted physiological differences. The belief that endocrinology is directly related to the limitations of the female to hypertrophy to the extent of the male is also supported by Clayton Thomas (1, p. 349), Klafs and Arnheim (2, p. 146), Brown and Wilmore (4, p. 177), and Wilmore (5, p. 137). Shaffer's summary statements were quite appropriate in terms of the differences of the sexes and considerations for physical performance:

> Evidence has been presented that from the sixth week of embryonic life there are anatomic and physiologic differences which affect physical growth and development. In the female, her pattern of growth and development leads to certain characteristics such as smaller body size and dimensions of organs, more body fat, leading to proportionately less muscle mass, reduced hemoglobin mass, physiologic variations related to the reproductive system after puberty. All of these require special consideration in programming physical activities and sports for women. However, while there are very significant sex-related differences between males and females, it should be borne in mind that there are undoubtedly greater differences between the third and the 97th percentile in each sex than there are differences between the average female and the average male in terms of physical performance (3, p. 330).

At the same research conference at Pennsylvania State University, Karl Stoedefalke presented a paper on training and conditioning techniques for the female athlete. After presenting the paper Stoedefalke concluded by saying:

> Perhaps women do have smaller hearts, higher heart rates, less muscle mass and significantly more body fat than men, but these do not deter them from participating successfully in athletics. We do not know what the female athlete is capable of doing over time because we have only begun to scientifically assess their potential ability (6, p. 337).

It is apparent that more scientific evidence concerning the physiological development of the female is necessary in order to assess their potential ability. The fact that more females are participating in vigorous activities and competitive sports than ever before, and the fact that this participation will broaden in scope, is further basis for the need for scientific study. The area of strength development and the consequent effects of strength training programs have received very little attention; however, if knowledge of the maximum performance levels of the female is to be gained, more scientific studies in this area must be conducted.

Statement of the Problem

The purpose of this study was to determine the effects of a progressive resistance exercise program on the development of strength, as measured by cable tensiometer; muscle girth, measured at selected body sites; and body composition, determined by skinfold fat measurements at selected sites, of a group of college women.

Hypotheses

1. There will be no significant difference in strength in the experimental group from pre-test to post-test on the following strength assessments: elbow flexion, elbow extension, shoulder adduction, shoulder horizontal adduction, plantar flexion, knee flexion, knee extension, trunk flexion.

2. There will be no significant difference in any of the strength assessments in the control group from pre-test to post-test.

3. There will be no significant difference in strength between the post-test scores of the experimental and control groups on the following strength assessments: elbow flexion, elbow extension, shoulder adduction, shoulder horizontal adduction, plantar flexion, knee flexion, knee extension, trunk flexion.

4. There will be no significant difference in muscle girth in the experimental group from pre-test to post-test on the following girth measurements: chest, waist, abdomen, hips, thigh, calf, upper arm.

5. There will be no significant difference in any of the muscle girth assessments in the control group from pre-test to post-test.

6. There will be no significant difference in muscle girth between the post-test scores of the experimental and control groups on the following girth assessments: chest, waist, abdomen, hips, thigh, calf, upper arm.

7. There will be no significant difference in skinfold fat measurements in the experimental group from pre-test to post-test at the following sites: tricep, subscapular, abdominal, iliac, thigh.

8. There will be no significant difference in any of the skinfold fat measurements in the control group from pre-test to post-test.

9. There will be no significant difference in skinfold fat measurements between the post-test scores of the experimental group and control group at the following sites: tricep, subscapular, abdominal, iliac, thigh.

The .05 level of confidence will be used for a basis of acceptance or rejection of the preceding hypotheses.

Sub-Problems of the Study

Accurate conclusions, to be arrived at through this study, are dependent upon valid and reliable assessments of strength, skinfold fat, and muscle girth from the pre- and post-training measurements. The Lange skinfold calipers, the Lufkin anthropometric tape, and the cable tensiometer (manufactured by Pacific Instrument Company) have been proven to be valid instruments for their respective assessments and have been accepted at face validity for this study. The cable tensiometer was the only instrument requiring a check for its accuracy; therefore, an up-scale calibration check was made to determine the accuracy of the tensiometer readings with the actual pounds pressure on the corresponding conversion scale.

The validity of the instruments used must also be supported by the establishment of reliable testing procedures which includes the reliability of the person administering these procedures. Therefore, reliability checks were conducted on each of the testing procedures.

The following were considered to be sub-problems to this study:

1. To determine the reliability of the strength testing procedures.

2. To determine the reliability of the skinfold fat measurement procedures.

3. To determine the reliability of the muscle girth measurement procedures.

4. To check the up-scale calibration of the cable tensiometer.

Limitations of the Study

1. The experimental group for this study consisted of Oklahoma State University female students, enrolled in HPER 1122 Body Mechanics and was not randomly selected.

2. The control group for this study consisted of Oklahoma State University female students, enrolled in HPER 1062 Theory of Sports II and was not randomly selected.

3. There was no attempt to control the diet or extra-curricular activities of either the experimental or control groups.

4. Due to the academic calendar, there was a one week lapse of time midway through the exercise program which was not included in the ten weeks of training.

Delimitations

1. This study was limited to college women, enrolled in Body Mechanics, HPER 1122, at Oklahoma State University during the spring semester, 1975.

2. Assessment of body composition was limited to selected skinfold fat measurements at the following sites: tricep, subscapular, abdomen, iliac, and thigh.

3. Assessment of muscle girths was limited to selected circumference measurements at the following sites: chest, waist, abdomen, hips, thigh, calf, and upper arm.

4. Assessment of strength was limited to cable tension strength tests of the following movements: elbow flexion, elbow extension, shoulder adduction, shoulder horizontal adduction, plantar flexion, knee flexion, knee extension, and trunk flexion.

5. The progressive resistance exercise program employed in this study was limited to exercises performed on the Universal Gym weight training apparatus.

6. The duration of the progressive resistance exercise program was limited to ten weeks.

Assumptions

1. It was assumed that the diet and extra-curricular activities of the control and experimental groups will have an equal effect on both groups.

2. The control group did not participate in programs or activities designed for strength development and/or programs designed for body composition changes.

3. All subjects exerted maximum efforts during the progressive resistance exercise program and the strength testing procedures.

Definitions

1. Progressive resistance exercise is a form of strength training, usually referring to weight training, employing progressive increases in workloads as strength increases in each exercise.

2. Strength is the ability of a muscle to exert force against a resistance.

3. Muscle girth is the circumferential measurement of a specified site of a muscle group or groups.

4. Body Composition is the distribution in the body of muscle, bone, and body fat, limited in this study to skinfold fat.

5. Hypertrophy is a term which indicates increased size of muscle fibers resulting in increased muscle mass.

6. RM is an abbreviation for repetition maximum, usually preceded by a number indicating the maximum repetitions a weight can be lifted. 1 RM would indicate the maximum weight a person could lift one time, likewise 10 RM would indicate the maximum weight a person could lift ten times.

7. Set is the designation of a group of repetitions to be performed in an exercise period.

8. Intensity of the Work Period is the designated number of sets to be performed for each exercise for a training session.

CHAPTER II

REVIEW OF RELATED LITERATURE

The scientific study of strength development through resistance exercise began in the early 1940's when Captain Thomas L. DeLorme, a United States Army Medical Doctor, was faced with the task of rehabilitating World War II veterans who had sustained pathological disabilities (7, p. 23). Up to this time, the use of heavy resistance, or weight training, was not considered as an acceptable method of improving strength due to the misconceptions of "muscle boundness" or the restriction of movement and flexibility caused by excessive muscle mass. There were no scientific studies to determine what the effects of heavy resistance exercise were in relationship to strength and muscle hypertrophy.

DeLorme was the first to study the effects of heavy resistance exercise on strength and muscle hypertrophy, and through his experiences in rehabilitative work, arrived at the first proposed exercise program using progressive resistance exercise. This program is known as the DeLorme-Watkins Technique of Progressive Resistance Exercise (8). It consists of: 1 set of 10 repetitions with 1/2 of the 10 RM, 1 set of 10 repetitions with 3/4 of 10 RM, and 1 set of the 10 RM. Using DeLorme's method of progressive resistance exercise as the foundation from which other programs were developed, we can study the scientific evolvement of the principles in progressive resistance exercise through studies that attempted to determine the most effective workloads and intensity of work periods suitable for maximum strength gains.

In 1946, Houtz, Parrish, and Hellebrandt (9) began their studies in progressive resistance exercise. Their first publication reported the effects of DeLorme's method of resistance exercise on sixteen female subjects. Their reported findings were that the strength of the subjects more than doubled in a four-week period.

In 1949, Krusen (10) compared two groups of male subjects training with different workloads of progressive resistance exercise. One group trained with 25 percent, 50 percent, and 75 percent of the 5 RM for the first, second, and third sets, respectively. The second group used the 5 RM for the first set, 125 percent and 150 percent of the 5 RM for the second and third sets, respectively. His reported findings showed no significant differences in strength between the two groups.

Clayton Henry (11), in 1949, conducted a study as a master's thesis, using himself as the subject. The DeLorme method was used on his left arm flexors and right leg extensors compared with a program employing 10 RM for the first set, the same weight as many times as possible the second set, and 75 percent of the 10 RM as many times as possible for the third set, on his right arm flexors and left leg extensors. At the end of eight weeks he found no significant differences in the effects of the two programs on strength and muscle hypertrophy.

Everett Faulkner (12), in 1950, conducted a follow-up study to Henry's for a master's thesis. His procedures were the same except he used a program employing 1/2 10 RM for the first set, the 10 RM for the second set, and 3/4 of the 10 RM for the third set, to compare with

DeLorme's method. His findings were: The DeLorme method produced a greater increase in strength, but the alternative method developed greater endurance.

In 1953, McGovern and Luscombe (13) compared the differential effects of three programs of progressive resistance exercise on male subjects. The first group used five repetitions with 1/2 of 10 RM for the first set and the 10 RM for the second set. The second group used the 10 RM for the first set, 3/4 10 RM for the second set, and 1/2 of the 10 RM for the third set. The third group used DeLorme's method. The results, after three weeks of training, showed no significant differences in strength between the three groups.

Allene Montgomery (14), in 1954, conducted a study on muscle hypertrophy following various exercise regimes. Ten girls were used in the six weeks study. With one arm the girls performed rapid exercises without weights and with the other arm they performed slow exercises with weights. There was no significance statement concerning the results; however, it was reported that the mean girths increased .30 inch in the arms using weights and .2375 inch in the arm using no weight, and endurance was reported as being increased more so in the arms using weights than the non-weighted arms.

McMorris and Elkins (15), in 1954, compared the DeLorme method to the modified Oxford Technique of progressive resistance exercise using male subjects. The Oxford Technique involved the same number of sets and repetitions as the DeLorme Technique except the order of performance was reversed. The findings after twelve weeks of training, showed no significant differences in strength between the two groups.

In 1956, Edward K. Capen (16) conducted a study of four programs of heavy resistance exercises for males on the development of muscular strength. The four programs are as follows: (1) eight to fifteen lifts of maximum weight for one set; (2) eight to fifteen lifts of maximum weight for one set plus five lifts of maximum weight for the second set; (3) five lifts of maximum weight in three sets; and (4) one lift of maximum weight, repeated three times. Capen concluded that the third program was superior to the other three, with significant strength gains at the .06 level of confidence. He also concluded that an exercise regimen consisting of three work periods weekly produced more satisfactory results than a regimen requiring exercise five times weekly.

F. A. Hellebrandt and Sara Jane Houtz (17, p. 383) after four years of research arrived at the following conclusions concerning the physiological basis underlying progressive resistance exercise:

1. Strength and endurance increase as a result of progressive resistance exercise.

2. The slope gradient of the training curve varies with the magnitude of the stress imposed, the frequency of practice sessions, and the duration of the overload effort.

3. Repetition of movements which do not cause neuromuscular stress have little effect on the functional capacity of skeletal muscle.

4. The amount of work done per unit of time is the critical variable upon which improvement in performance depends.

5. Changes in the central nervous system appear to be an important effect of training.

6. The ability to develop maximal tension appears to be dependent on the proprioceptive facilitation with which overloading is associated.

7. The foregoing conclusions do not shed any light on the respective values of the different systems of exercise which have been recommended in the literature.

In 1958, Philip J. Rasch (18) published a comprehensive review of these studies in progressive resistance exercise. The scientific quality, by today's standards, of some of the studies may be in question; nevertheless, they represent the attempts during that time span from the 1940's to determine the effects of various methods of strength training and the underlying principles involved. Rasch, in the concluding statements to his review of progressive resistance exercise through 1958 makes the following observations: regimens of progressive resistance exercise are largely empirical, and little information is available concerning the relative advantages of the various programs which authorities have recommended; the physiological mechanism by which muscular strength and hypertrophy are increased and the relationship between changes in these attributes is not clear; there is no evidence that undesirable neuromuscular effects result from progressive resistance exercise.

The research during this time span has supplied us with very little scientific evidence in regards to the most efficient workloads and degree of intensity of work duration for producing the greatest strength gains. The most important results from this research was that progressive resistance exercise became recognized as a highly valid method of producing strength gains, and with the establishment of this fact more scientific research was stimulated in various physiological aspects of progressive resistance exercise.

During the period of the early 1960's, more research, in terms of quality and design, was being produced. Researchers became more aware of the direct relationships of the amount of workload, the intensity of the work period or duration, and the number of exercise sessions per week, on strength development and muscle hypertrophy. It was also recognized that scientific evidence was necessary in order to eliminate the previous myths and misconceptions concerning progressive resistance exercise and that sound principles needed to be established upon which programs of progressive resistance exercise would be based.

Vernon Barney and Blauer Bangerter (19) conducted a study at Brigham Young University in 1961 using male subjects comparing three programs of progressive resistance exercise. This study focused on claims by I. J. MacQueen (20) which were not backed by scientific evidence. MacQueen's claims were that his suggested traditional maximum methods for increasing power and hypertrophy brought about quicker and greater gains than methods suggested up to that time and advocated the use of these methods in rehabilitation efforts in preference to the fractional methods then employed. Barney and Bangerter compared MacQueen's two programs: (1) the traditional bulk program of 3 sets of the 10 RM and (2) the traditional power or strength program of one set of the 10 RM, the second set of as many reps as possible with a 5-10 pound increase of the 10 RM, and subsequent sets, increasing each set 5-10 pounds until the 1 RM is reached at which time one more lift of a heavier weight is attempted, with the DeLorme-Watkins method. Initial and final measurements were taken on muscular circumference and strength. Their findings were contradictory to MacQueens claims in that only the DeLorme method showed significant circumferential gains and that there were no significant differences between the three programs in terms of strength development.

In 1962, Richard A. Berger, a well known authority who has made significant contributions in the areas of progressive resistance exercise, began a series of studies at Texas Technological College. The background for these studies began in 1956 when Berger (21) conducted a study on progressive resistance exercise for his master's thesis at

Michigan State University. In this study Berger compared strength improvements between three groups of college men over a five-week period. The first group trained with 3 sets of the 2 RM. The second group trained with 3 sets of the 6 RM and the third group trained with 3 sets of the 10 RM. The results of this study showed no significant differences in strength between the three groups. In 1960, Berger (22) conducted a second study involving college males comparing nine different weight training programs in order to define the optimum number of sets and repetitions per set to improve strength. The experiment was limited to one exercise, the bench press lift, three times a week for a twelve-week period. The nine various exercise programs were derived from combinations of one, two, and three sets using two, six, and ten repetitions per set. The results showed that three sets and six repetitions per set were best for improving strength.

In 1962 at Texas Technological College, Berger began a series of studies in an effort to more clearly define the optimum number of repetitions per set for best strength gains and to better determine the effects of programs using heavier workloads with fewer repetitions and lighter workloads with more repetitions. The first study (23), reported in the Research Quarterly in 1962, was to determine the optimum number of repetitions per set to perform for the greatest strength gains. Nine groups totaling 199 male college students, trained three times a week for twelve weeks employing either the 2 RM, 4 RM, 6 RM, 8 RM, 10 RM, or 12 RM for one set. The findings were that the optimum number of repetitions was between three and nine. Again in 1962, Berger (24) conducted a study to determine whether strength would develop faster with fewer repetitions and heavier loads or with more repetitions and lighter loads and whether fewer or more sets were desirable. The study included 177 male college students training three times a week for a twelve-week period. The different programs employed were: (1) one set, 2 RM; (2) one set, 6 RM; (3) one set, 10 RM; (4) two sets, 2 RM; (5) two sets, 6 RM; (6) two sets, 10 RM; (7) three sets, 2 RM; (8) three sets, 6 RM; (9) three sets, 10 RM. The conclusions arrived at from this study provide a considerable amount of information for selection of a progressive resistance exercise program in which maximal strength gains are desired. Berger's conclusions were:

1. Progressive resistance exercise involving all possible combinations of one, two, and three sets and two, six, and ten repetitions per set improved strength significantly.

2. The groups reacted homogeneously to a wide variety of progressive resistance exercise programs. The different training programs did not tend to accentuate differences between subjects in any one group.

3. Training with all combinations of one, two, and three sets and two, six, and ten repetitions resulted in rates of strength improvement which differed more as training continued.

4. Training with three sets each session produced a greater improvement in strength than training with one or two sets at 6, 9, and 12 weeks of training. One set appeared just as effective in improving strength as two sets.

5. Progressive resistance exercise with six repetitions per set improved strength more than training with two repetitions per set at 9 and 12 weeks of training. After nine weeks of training, ten repetitions per set resulted in greater strength improvement than training with two repetitions. But after twelve weeks of training, two repetitions per set was as effective as training with ten repetitions per set.

6. Training with one, two, or three sets in discrete combination with two, six, or ten repetitions per set (interaction) was not systematically more effective in improving strength than other combinations. The significant differences in strength improvement appeared due primarily to training with three sets and six repetitions per set, which were consistently more effective than one or two sets and ten or two repetitions, rather than to interaction.

7. Strength did not improve consistently faster when heavier loads were employed for few repetitions (2 RM) or when lighter loads were employed for higher repetitions (10 RM). The optimum number of repetitions per set for improving strength was somewhere between the two extremes. Training with 6 RM was the optimum or appeared to be nearer the optimum for improving strength than training with 2 RM or 10 RM. Training with three sets was nearer the optimum number for improving strength faster than one or two sets. A combination of 6 RM performed for three sets was more effective in improving strength than any other combination of sets and repetitions per set (24, pp. 180-181).

In 1963, Berger (25) reported a study in the Research Quarterly, which was prompted by an interest in programs used by competitive weight lifters, comparing the effects of frequent sets, heavy loads, and few repetitions with programs of fewer sets, lighter loads and more repetitions. It was stated that competitive lifters train with loads of 1 RM - 5 RM, for at least four sets and as high as ten sets. With this in mind, Berger compared the following programs: Group I - six sets, 2 RM; Group II - three sets, 6 RM; and Group III - three sets, 10 RM. The study was conducted for nine weeks using 48 male college students. From the results, Berger concluded that training for nine weeks, three times weekly, with heavy loads for few repetitions per set and numerous sets was not more effective for improving strength than training with lighter loads for more repetitions per set and fewer sets. However, Berger states that the optimum number of repetitions for greatest strength gains may vary as the number of sets increases; thus, further research is necessary to determine the optimum combination of sets and repetitions for greatest strength gains.

Some basic principles, arrived at by Berger through his research, have been stated in a publication by the President's Council on Physical Fitness and Sports on weight training for strength and power:

1. Training with submaximal loads of as low as two-thirds or more of maximum strength twice weekly, and maximal loads once weekly will result in as much strength improvement as training maximally three times weekly.

2. The load with which to train for optimum improvement in strength, when training three times weekly for one set each, lies between the 3 RM and 9 RM.

3. Training with the 2 RM for six sets, three times weekly, is as effective for increasing strength as training with the 6 RM for three sets, three times weekly.

4. Training with the 6 RM for three sets, three times weekly is more effective for increasing strength than training with either the 2 RM or 10 RM for three sets, three times weekly.

5. Training once weekly with the 1 RM for one set will increase strength significantly after the first week of training and each week up to at least the sixth week.

6. Weight training with the 10 RM for three sets, twice weekly, is just as effective for increasing strength as training the same way three times weekly.

7. No particular sequence of performance in training with different proportions of 10 RM maximum strength will be more effective than any other sequence for strength improvement as long as one set of 10 RM is performed each training session.

8. Three sets for each lift are more effective for increasing strength than training for one or two sets.

9. The number of training days per week for optimum improvement in strength is not known. Significant increases have occurred training one day weekly to five days per week for beginners, but in these instances only one lift was performed.

10. Training with several lifts, four or five days per week, may not be as effective for increasing strength as training the same way two or three times per week. The greater muscular fatigue experienced from training more frequently may prevent sufficient recuperation between training sessions and, therefore, reduce the rate of progression.

11. A program of three training sessions per week, provided the number of different lifts is not excessive, should not be too few for excellent results. A beginner should start with eight to ten lifts and then add or reduce this number according to his recuperative ability. A fourth workout per week may be added later when the individual attains improved physical condition (26, pp. 3-5).

The review of the literature thus far has concentrated on various programs of progressive resistance exercise which have employed numerous combinations of workloads, duration or intensity of work periods, and frequencies of work periods, in an effort to arrive at some basic principles in regard to progressive resistance exercise. The focus of the following research will be directed at the area of progressive resistance exercise for women and its effects on strength, anthropometric measurements, and body composition.

A study was conducted at the University of Tennessee in 1961 by Bright, Capen, and Line (27) which included the effects of weight training on strength and anthropometric measurements of college women. A group of fourteen female physical education majors were selected as subjects for the study. The training program defined in the study, reports only that the workload was with heavy weights allowing few repetitions and that training occurred three times weekly for ten weeks. Strength, prior to and at the conclusion of the training period, was measured by the standing broad jump, a pull-up test, a sit-up test, a grip manuometer, and a back and leg dynamometer. Anthropometric measurements included: height, weight, chest girth, waist girth, thigh girth, hip girth, and calf girth; skinfold measurements at the chest, waist, and back of the arm. The results of this study showed significant strength improvement in all areas tested. As for anthropometric measurements, the only significant change was a decrease in the waist skinfold measurement, the other measurements showing no significant changes.

A study by Norma Sue Griffin (28) in 1961 was conducted to determine the effects of a weight training program for college women on strength development. The modified weight training program consisted of exercises performed with light weights as a part of a developmental course in physical education. Strength was measured prior to and at the conclusion of a six-weeks training period for trunk flexion, right knee extension, right shoulder flexion, right elbow flexion, right elbow extension, and right ankle plantar flexion, by the cable tensiometer. The findings indicated significant strength improvement in all six areas tested.

Sue Anne Brown (29), in 1965, conducted a five-week study on the effects of a heavy resistance exercise program on anthropometric measurements. Eleven college women were divided into two groups, one working with heavy resistance on the upper body and the other working with heavy resistance on the lower part of the body. At the end of the five-week period there were no significant changes in body measurements at the upper arm, chest, waist, hips, two thigh measurements and the calf.

A study by Julia Anne Hudson (30) was conducted in 1966 on the effects of weight training on strength and motor ability of college women. Thirty-nine college women participated in a ten-week weight training course and were tested prior to and at the conclusion of the course for strength and motor ability. Grip strength, leg strength, back strength, pull-ups, and sit-ups were included in the strength test battery. At the end of ten weeks of training, the results showed a significant increase in motor ability and significant increases in strength. Gains in leg strength, pull-ups, and sit-ups were statistically significant at the .05 level of confidence, whereas grip strength and back strength improved but not enough to be statistically significant at the .05 level of confidence.

At South Dakota State University in 1967, Vicky Larson (31) studied the effects of a progressive weight training program on arm and leg strength, resting heart rate, body adipose tissue, and selected body measurements of college women. Thirty women completed twenty-four training sessions in a period of seven weeks. The training was done on a Marcy Gymnasium (which is similar to the now popular Universal Gymnasiums). From the results of this study, it was concluded that: There were no significant increases in arm and leg strength; the program had no significant effect on resting heart rate; there was no significant difference on any of the selected body measurements; however, there was a significant loss of adipose tissue on the cheek, chest, arm, back, hip, and abdomen.

In 1968 at Oak Grove Lutheran High School in Fargo, North Dakota, Karen Olson (32) studied the effects of a minimal weight training program on high school girls. The training sessions were administered twice weekly for fifteen minutes a session over a five-week period. Twenty-four subjects participated in the weight training program. The subjects were tested on six physical fitness items and five body measurements were taken before and at the end of the five weeks of training. The results showed no significant differences on neither the six physical fitness items nor the five selected body measurements.

Caren Franci (33) conducted a study in 1968 at the University of California at Santa Barbara, on the effects of overload and endurance exercises on anthropometric measurements of overweight college women. Thirty college women classified as "slightly-moderately overweight", were divided into two groups. Group I used a progressive resistance exercise program with a workload of 10 RM. Group II employed an endurance program beginning with the 10 RM and continually increasing repetitions without increasing the workload. The training sessions lasted for a period of six weeks. The results of the study revealed that both programs produced decreases in body fat and increases in muscular density.

Allene Shore (34), in 1969, studied the effect of a weight training program for high school girls on the California Physical Performance Test. A group of high school girls was divided into an experimental group, which participated in a weight training program three days a week and the regular class sessions on the other two days, and a control group which participated only in the regular class sessions. Both groups were tested on the California Physical Performance Tests before and after the six weeks training period. The results showed the experimental group improving on the tests more than the control group; however, there were no significant differences statistically between the two groups.

The effects of a weight training program on physically underdeveloped high school girls were studied by Dianna McKellar (35) in 1970. The California Physical Performance Tests were administered prior to and at the conclusion of a six-week weight training program. A total of eighty-six underdeveloped high school girls were used as subjects. The findings showed significant improvement in performance on the standing broad jump, bent knee push-up, and bent knee sit-ups.

Virginia Husted (36) conducted a study at the University of Washington in 1971 on the effect of a voluntary program of resistance exercises and jogging on the modification of strength, endurance, and subcutaneous fat of women. Forty-eight subjects participated in a five-week program consisting of progressive resistance exercises and jogging.

The results of the study showed significant improvement in arm, shoulder, and leg strength, significant improvement in endurance as measured by the Skubie-Hodgkins Cardiovascular Efficiency Test, and significant fat losses at subscapular and supra-iliac sites.

Recently, Harmon Brown and Jack Wilmore have published studies relating specifically to the effects of resistance training on strength, anthropometric measurements and body composition of women. The first study (4) was conducted in 1970 and published in a recent issue of Medicine and Science in Sports. This study concerned the effects of maximal resistance training on the strength and body composition of women athletes. Seven nationally ranked track and field throwing event athletes, aged 16-23 years, were subjects for the study. These subjects were highly motivated to undertake intensive training consisting of three training sessions per week and performing five to six sets of decreasing repetitions with increased workloads, beginning with 10 RM and progressively increasing the workload to 3 RM. These 1-1½ hour sessions were continued over a six-month period. Two of the seven subjects chose not to use weight training as part of their program. Strength was tested using the 1 RM, eight circumference and six skinfold measures were taken on each subject prior to and at the conclusion of the six months of training. The results showed substantial strength improvement in all subjects training with weights; of the subjects not training with weights, one improved leg strength but neither showed any other strength gains. Girth changes in the upper extremities increased in all subjects regardless of weight training experience. However, there were no significant changes at the remaining sites. Although strength gains were quite evident in those subjects who weight trained, the average lean body weight increased less than 1 kg during the six-month period. Brown and Wilmore noted that in contrast to males who weight train, lean mass increases of 1-2 kg in only a few weeks is quite common. As stated by Brown and Wilmore, considerable hormonal differences between men and women, particularly testosterone which is the most potent androgen produced by the testes is a major factor allowing males to achieve a greater degree of muscular hypertrophy.

Wilmore (5) reported another study conducted in 1973 in a recent issue of Medicine and Science in Sports. This study concentrated on alterations in strength, body composition and anthropometric measurements resulting from a ten-week weight training program. This study was designed to study these alterations on both 26 male and 47 female subjects simultaneously training on the same program. The training program consisted of two-sets 7-9 RM of nine exercise lifts, twice weekly. The results showed significant strength increases for both males and females on each of the nine strength exercises. Changes in body composition were nearly identical for males and females, weight remained stable, lean body weight increased and body fat decreased. Statistically significant increases in girth were reported for both males and females, with the males showing substantially greater gains than the females.

The most recent research publication concerning body composition changes of the female following a program of high resistance weight training was reported by Mayhew and Gross in the December 1974 issue of the Research Quarterly (37). The high resistance weight training program consisted of nine weeks of training, three day per week, and 40 minutes per session. A circuit training method was used employing the 10 RM as the workload for each of the nine exercises, performing two sets of each exercise per session. Twenty-seven college females were used as subjects, 17 in the experimental weight training group and 10 in the control group. Pre-training and post-training measures were taken for total body potassium, seven skinfold thicknesses, eight muscular girths, and four skeletal diameters. Strength was assessed by evaluating the initial and final 10 RM values, plus a grip strength test using a Stoelting dynamometer. The results of this program on the experimental group revealed significant increases in total body potassium, lean body mass, flexed biceps and forearm girths, and shoulder width. Relative fat and chest depth were significantly decreased while skinfold thicknesses and body weight were unaffected. The experimental group also showed significant strength gains for each exercise performed. The sedentary control group showed no significant changes in any of the measured parameters. Mayhew and Gross concluded that high resistance weight training can enhance feminine body composition without concomitant masculinizing effects or marked changes in body weight.

Summary

Research on progressive resistance exercise began in the 1940's with the work of Thomas L. DeLorme. The scientific evidence produced from this time until 1960 revealed very little in terms of the most efficient workloads and intensity of work periods necessary for optimal strength development. However, the studies conducted by Krusen (10), McGovern and Luscombe (13), McMorris and Elkins (15), and Capen (16) supplied substantial evidence supporting the fact that significant strength development could be achieved by numerous combinations of workloads, sets, and repetitions employed in varying program designs. The important contribution was the establishment of resistance exercise as a desirable method of significant strength development.

Berger (21) (22) (23) (24) (25) in the early 1960's, made significant contributions toward the establishment of principles concerning the workloads, repetitions, sets, and frequency of training periods for the most efficient strength gains. These principles are commonly accepted as a basis for designing training programs as well as the basis for further research in these areas.

The review of the literature focusing on progressive resistance exercise programs for women, produced some evidence of strength development through resistance exercise but very little evidence reflecting the effects of the programs on body composition. Bright, Capen, and Line (27), Brown and Wilmore (4), Wilmore (5), and Mayhew and Gross (37) contributed the most significant evidence concerning strength development and body alterations in female subjects. Bright et al. substantiated significant strength gains in their subjects with no significant changes in anthropometric measurements. Brown and Wilmore's study of seven nationally ranked track and field throwing event athletes may be questionable in terms of the selection and number of subjects; however, the results of the study were impressive. Highly significant strength gains were reported after six months of intensive progressive resistance exercise training with significant muscle girth changes occurring only in the upper arms which reflects their specific training for the throwing events. Wilmore's study of 47 female subjects participating in a progressive resistance exercise program simultaneously with 26 males again showed significant strength gains; however, in contrast to other studies, there were statistically significant girth increases in the females, thus the question arises as to what extent will the female's muscles hypertrophy. Mayhew and Gross also report significant strength gains with increased girth measurements in the flexed biceps and forearm; however, their subjects showed significant increases in lean body mass without total body weight increases or significant increases in the other five girth measurements.

Several master's theses were reported in the literature concerning progressive resistance exercise programs for women. The majority of these are questionable in terms of their design. Many were conducted either over short periods of time, with abbreviated work periods, questionable workloads, or a minimal number of subjects. Larson's (31) study, although the duration was seven weeks, revealed significant strength gains with no significant girth increases and significant loss of adipose tissue. Franci's (33) study focusing on endurance exercises, of a progressive resistance program produced decreases in body fat and increases in muscular density in a six-weeks period. The only other master's thesis reported offering relevant information was Husted's (36) study which was a combined resistance exercise program with jogging. The results of a five-week training session revealed significant strength and endurance improvement with significant decreases in body fat.

The review of the literature reveals only a few studies which have concentrated on the specific effects of heavy resistance exercise on the strength development and body composition of the female. The results of these studies substantiate the fact that women will make significant strength increases through heavy resistance programs. However, the differences reported in muscular girth changes and skinfold thicknesses are not conclusive. From the reported research it can be stated that the scientific evidence to date, revealing information concerning the effects of progressive resistance exercise on women, is only the beginning of the needed research in this area.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to determine the effects of a progressive resistance exercise program on strength development, muscle girth, and body composition of college women. This chapter will outline: the selection of subjects; the methodology and procedures used in assessing strength, muscle girth, and body composition; the standardization of assessment procedures; the progressive resistance exercise program used for strength development; and the methods and procedures of statistical analysis.

Selection of Subjects

The subjects for this study consisted of 52 college females enrolled at Oklahoma State University. The experimental group consisted of 32 women enrolled in the course Body Mechanics, HPER 1122. The nature of the class and the design of the study were explained to the initial class of 36 women, at which time 30 exercised the option to continue as volunteers for the study. During the preparatory two weeks, prior to the starting of the progressive resistance exercise program, four women added the course as additional volunteers. During the ten weeks of training two women dropped out of the study, thus the total number of experimental subjects at the conclusion of the study numbered 32.

The control group consisted of 20 female students enrolled in

Theory of Sports, HPER 1062. The 20 control subjects were selected from volunteers based on their participation in activities which were similar to the activities of the experimental subjects.

All subjects agreed not to participate in any extracurricular activities which were designed for strength development or body alterations. It was also agreed upon that all subjects would follow their normal dietary patterns. Thus, all subjects followed their normal activity and dietary patterns with the exception of the experimental group, who participated in the progressive resistance exercise program.

Strength Assessment Procedures

The instrument used to assess strength in this study was the cable tensiometer. This instrument was originally designed to measure the tension of aircraft control cables; however, through modification, it has gained widespread use as an instrument for assessing human strength. Cable tension is determined by testing the force applied to a riser on the tensiometer, causing an offset in the cable which is stretched taut between two sectors. This tension is then converted directly into pounds of pressure on a conversion chart supplied with the instrument. Figure 1 shows the cable tensiometer, the conversion chart, and the regulation strap used in the strength testing procedures. Figure 2 shows the testing table and all of the accessory equipment used in the strength testing procedures.

The strength assessments were administered by the investigator and a qualified research assistant prior to and at the conclusion of the ten weeks of progressive resistance exercise. All subjects were instructed as to the proper execution of each test to be performed and

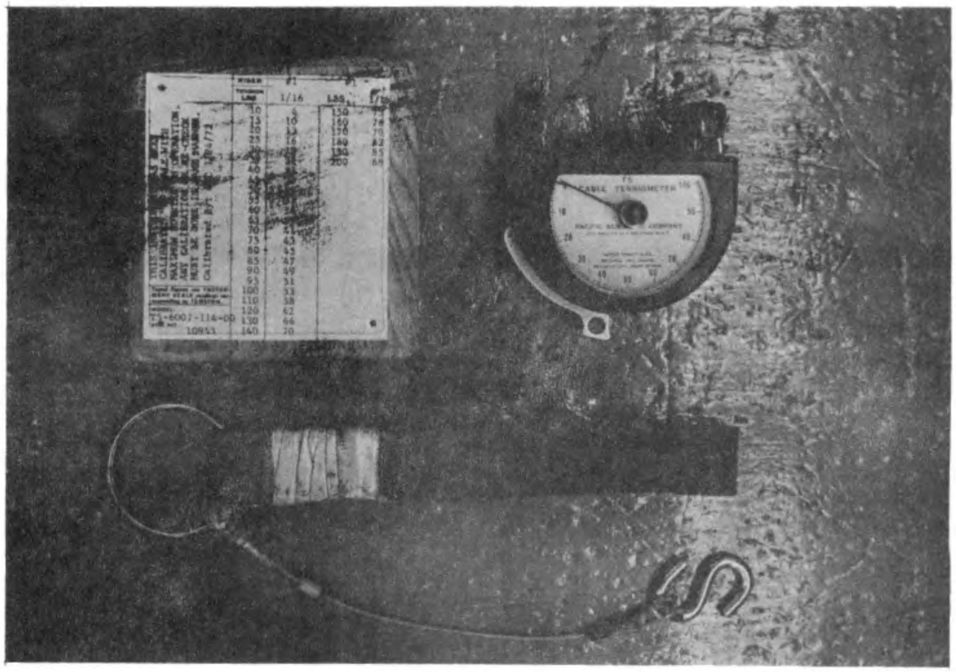

Figure 1. Cable Tensiometer, Conversion Chart, Regulation Strap

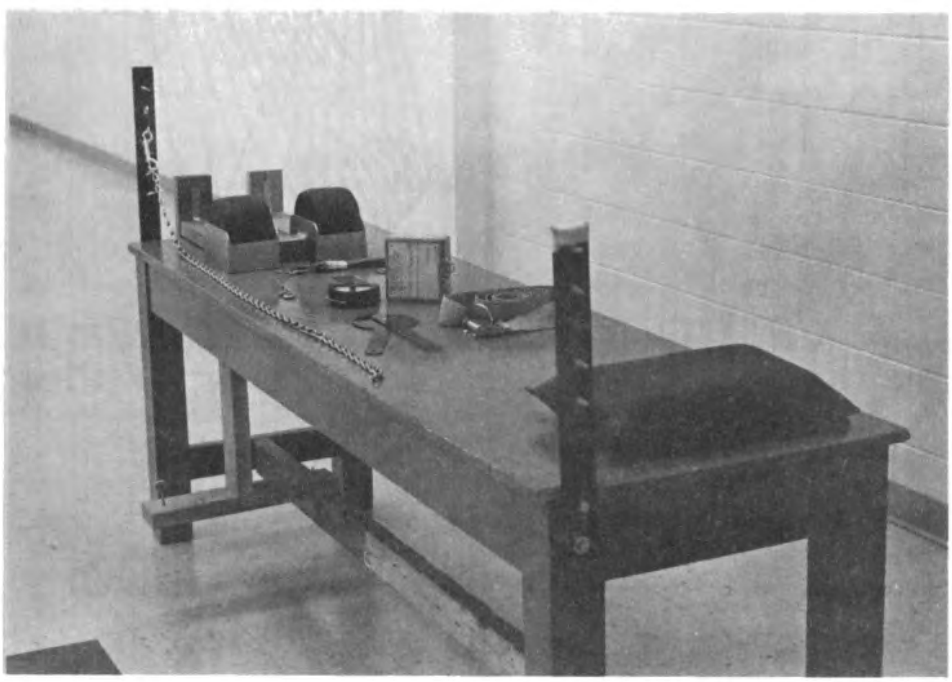

Figure 2. Testing Table and Apparatus

each subject received verbal encouragement from the investigator while performing two maximal efforts for each test. The highest recorded reading for each test was used as the assessment of maximal strength. This procedure was used on both pre- and post-assessments for the following strength tests: elbow flexion, elbow extension, shoulder adduction, shoulder horizontal adduction, plantar flexion, trunk flexion, knee extension, and knee flexion.

H. Harrison Clarke and Richard A. Munroe (38) list five basic directions for administering cable tension strength tests which were used in the strength assessment procedures of this study. The procedures used for administering the tests of trunk flexion, knee extension, and plantar flexion were adapted from Clarke and Munroe (38). The procedures for the remaining tests were established for the testing situation required in this study. Illustrations for each test are included in Figures 3 through 10 following each described test. The following are the procedures which were used in administering each of the tests.

Elbow Flexion

Starting Position. The subject assumed the supine lying position, with the hips and knees comfortably flexed, and the left hand and arm resting flat on the table. The upper right arm was in the resting position on the table, adducted, with the elbow flexed at 90 degrees.

Attachments. A regulation strap was placed around the right forearm midway between the elbow and wrist. The pulling assembly was attached to the table end brace at the foot of the table and perpendicular to the right forearm.

Bracing. The subject was braced by application of pressure to the lower legs and hips, preventing a sliding movement of the body with the pull on the cable.

Elbow Extension

Starting Position. The subject assumed the supine lying position, legs extended at 180 degrees and adducted, the shoulders firmly positioned against the shoulder brace, the left hand and arm resting at the side on the table. The upper right arm was resting on the table and adducted, with the elbow flexed at 90 degrees.

Attachments. A regulation strap was placed around the right forearm midway between the elbow and wrist. The pulling assembly was attached to the table end brace at the head of the table and perpendicular to the right forearm.

Bracing. Pressure was applied at the hips to prevent elevation and rotation.

Shoulder Adduction

Starting Position. The subject assumed the supine lying position with the legs extended at 180 degrees and adducted. The shoulders were positioned firmly against the shoulder brace, the left hand and arm resting at the side on the table. The upper right arm was adducted at 90 degrees to the shoulder, the elbow flexed at 90 degrees, and the right forearm parallel with the table.

Attachments. A regulation strap was placed around the upper right arm midway between the elbow and shoulder. The pulling assembly was

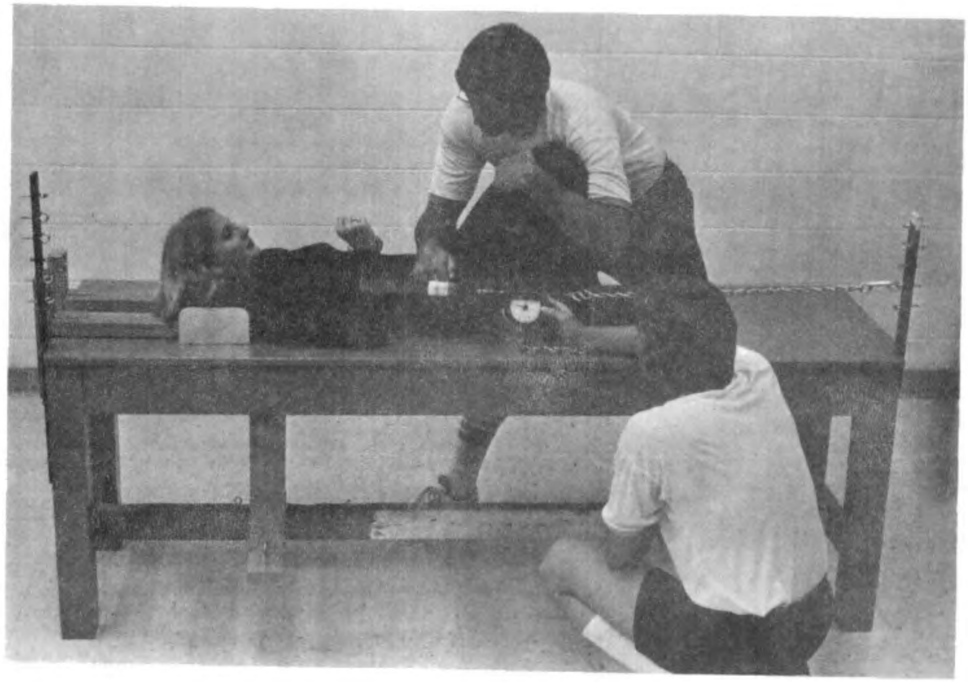

Figure 3. Elbow Flexion

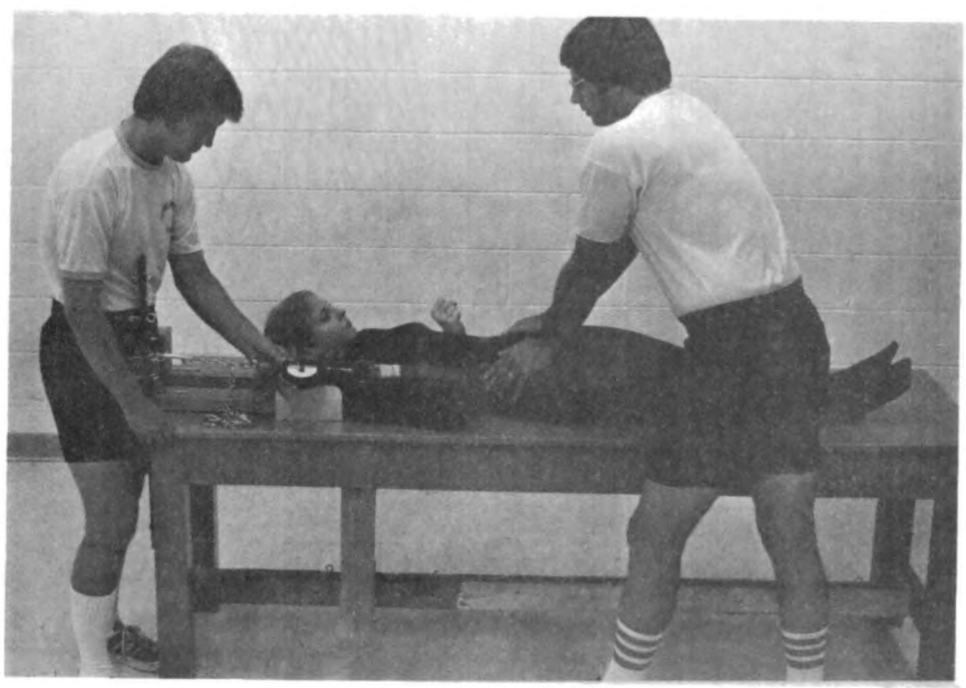

Figure 4. Elbow Extension

attached to the table end brace at the head of the table and perpendicular to the upper arm.

Bracing. Pressure was applied to the hips to prevent elevation and rotation.

Shoulder Horizontal Adduction

Starting Position. The subject assumed the supine lying position with the legs extended at 180 degrees and adducted. The shoulders were positioned firmly against the shoulder brace, with the left hand and arm resting at the side of the table. The upper right arm was adducted at 90 degrees to the shoulder, the elbow flexed at 90 degrees, and the right forearm perpendicular to the floor.

Attachments. A regulation strap was placed around the upper right arm midway between the elbow and shoulder. The pulling assembly was attached to the side brace at the base of the table parallel to the upper arm and the assembly was perpendicular to the upper arm.

Bracing. Pressure was applied at the hips to prevent elevation and rotation.

Plantar Flexion

Starting Position. The subject assumed the supine lying position with the legs extended at 180 degrees and adducted. The shoulders were positioned firmly against the shoulder brace with the arms extended by the sides of the body and resting on the table. The right foot was positioned so that the angle at the ankle was at 90 degrees with the lower leg and the sole of the foot was perpendicular to the lower leg.

Attachments. A regulation strap was placed around the upper sole

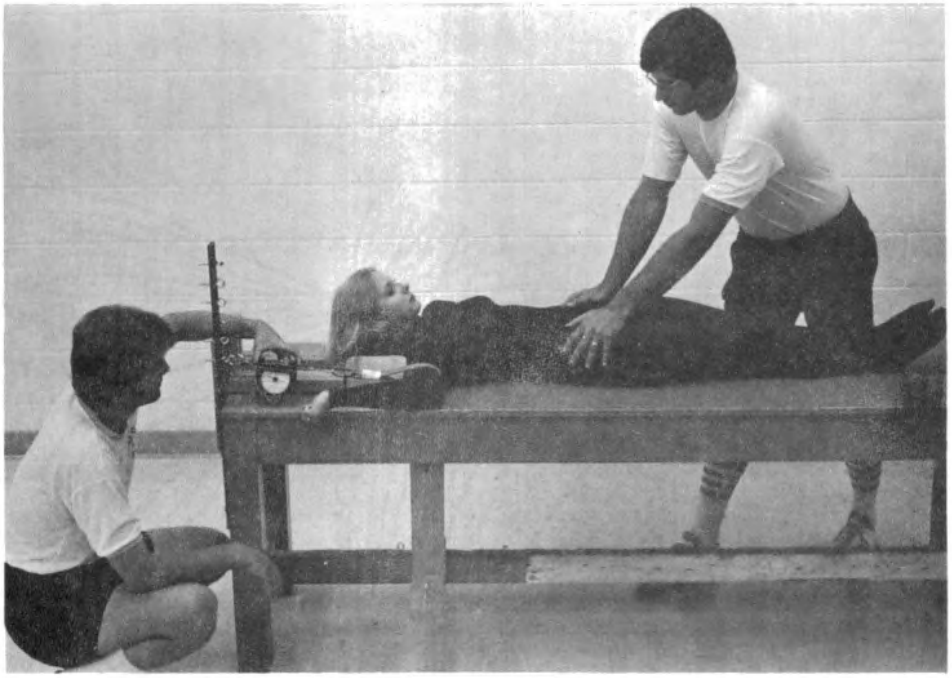

Figure 5. Shoulder Adduction

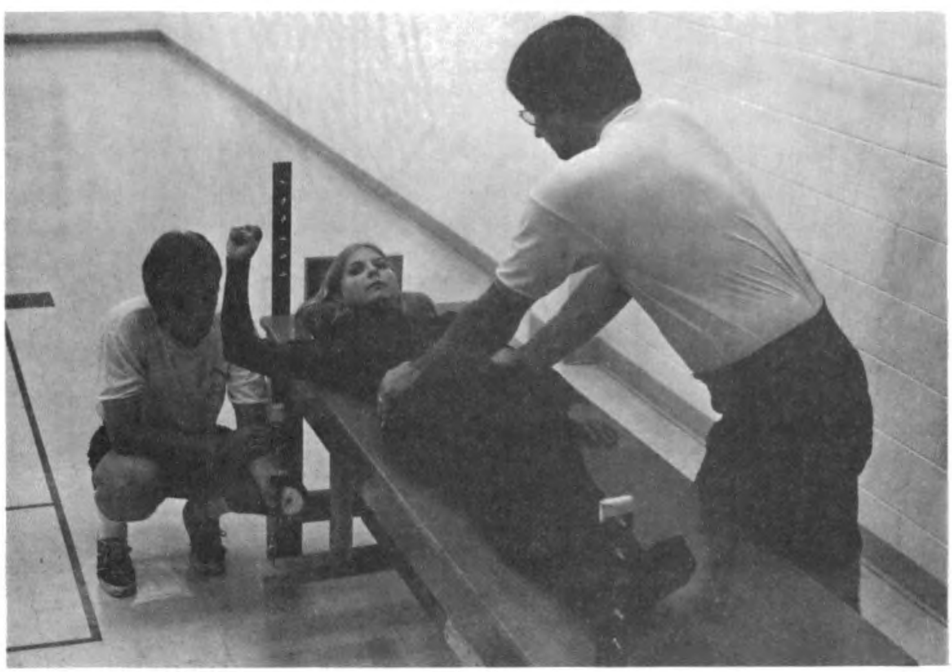

Figure 6. Shoulder Horizontal Adduction

of the right foot of the metatarsal arch. The pulling assembly was attached to the end brace at the head of the table perpendicular to the site of the strap attachment at the metatarsal arch.

Bracing. Pressure was applied on the right thigh just above the knee and at a point on the lower leg just below the knee to prevent flexion at the knee and lateral leg movement.

Trunk Flexion

Starting Position. An adjustable strap with an O ring attachment was secured around the subject at the arm pit level so that the O ring was located between the scapulae and in line with the spine. The subject assumed the supine lying position with the O ring projecting through the opening in the upper end of the table. The arms were folded across the chest and the hips and knees were comfortably flexed with the soles of the feet resting on the table.

Attachments. The cable of the regulation strap was attached to the O ring and the pulling assembly connected the cable to the center brace of the table directly below the O ring attachment.

Bracing. The subject was braced by application of pressure to the lower legs and hips, preventing a sliding movement of the body as the subject attempted the trunk flexion movement.

Knee Extension

Starting Position. The subject assumed an upright sitting position at the foot of the table. The trunk was upright and perpendicular to the table, the arms adducted at the sides with the hands resting on the table. The knees were directly over the end of the table, the left

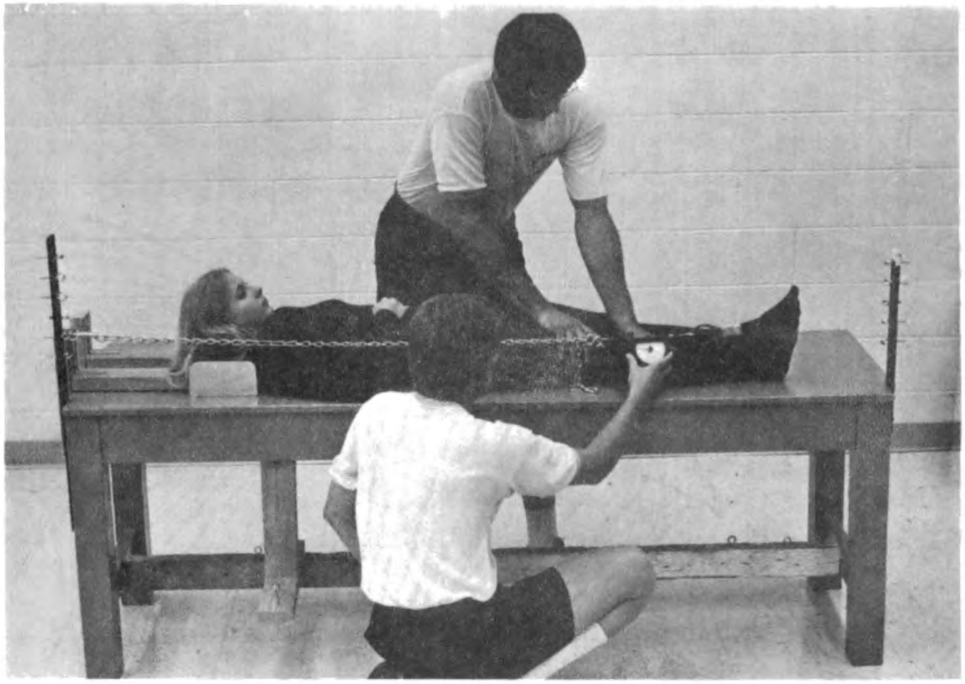

Figure 7. Plantar Flexion

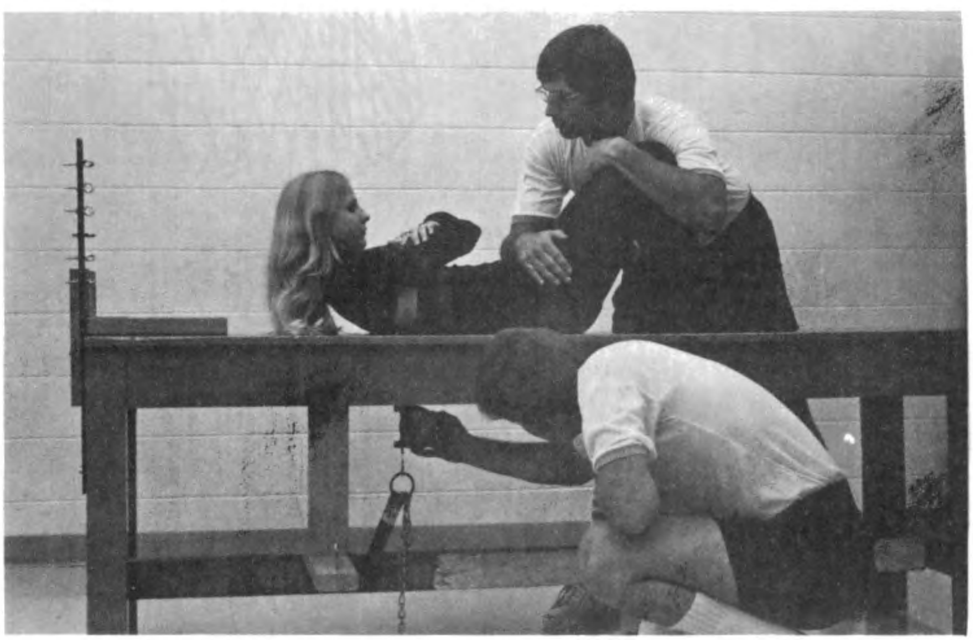

Figure 8. Trunk Flexion

leg hanging at 90 degrees and the right leg flexed at 65 degrees.

Attachments. A regulation strap was placed midway between the knee and ankle of the lower right leg. A small pillow was placed directly under the thighs just above the knee to prevent the table from cutting into the leg upon extension. The pulling assembly was attached to the center brace at a point perpendicular to the site of the regulation strap placement.

Bracing. The subject was braced by application of pressure around the shoulders to prevent trunk elevation through hip flexion and also on the right thigh just above the knee to prevent lateral movement of the leg.

Knee Flexion

Starting Position. The subject assumed the prone lying position, the head resting on the hands on the table, the left leg was extended at 180 degrees and adducted, while the right leg was flexed at 45 degrees with thigh resting on the table.

Attachments. A regulation strap was placed around the lower right leg, midway between ankle and knee. The pulling assembly passed through an opening in the table and attached to the center brace, perpendicular to the lower right leg.

Bracing. Pressure was applied at the back of the thigh above the knee and at the upper portion of the buttocks preventing any sliding movement of the body with the pull on the cable.

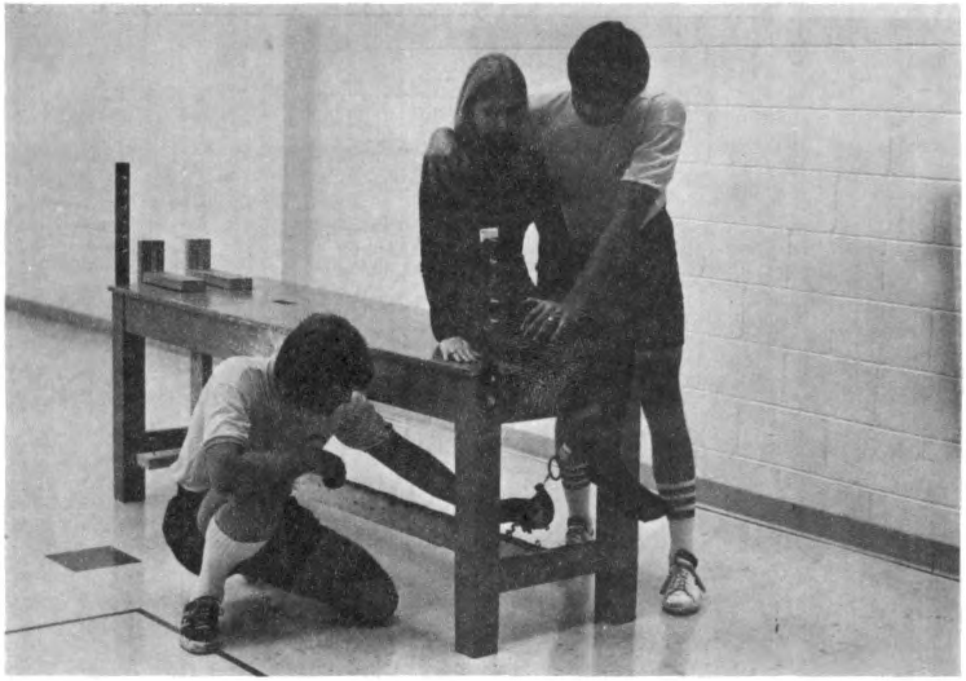

Figure 9. Knee Extension

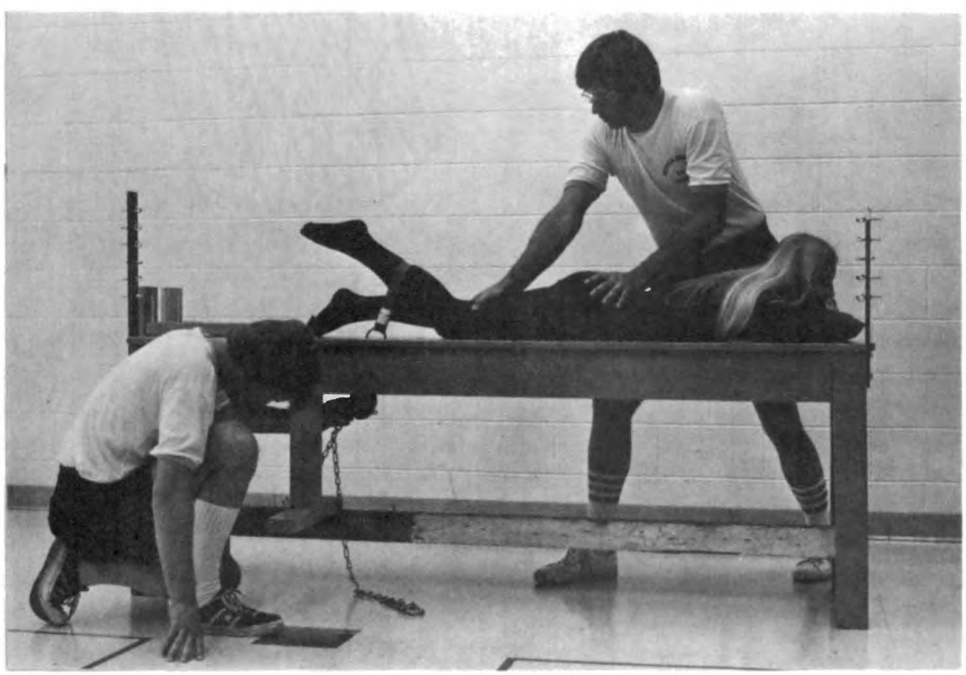

Figure 10. Knee Flexion

Muscle Girth Assessment

The procedures for muscle girth assessment were administered by a qualified female who has had previous experience in taking anthropometric measurements. These assessments were taken prior to and at the conclusion of the ten-weeks progressive resistance exercise program. A Lufkin anthropometric tape, measuring in centimeters, was used to assess the muscle girths. Two consecutive measurements were taken at each site and the average of the two measurements was used as the most accurate assessment of muscle girth. The following sites were used for muscle girth assessment: right upper arm, chest, waist, abdomen, hips, right thigh, and right calf. The subjects were measured without clothing and each site was measured to the nearest tenth of a centimeter.

The procedures described by Albert R. Behnke in "Anthropometric Fractionation of Body Weight" (39) were adapted for muscle girth assessments of the right upper arm, waist, abdomen, hips, and right calf. For each assessment the anthropometric tape was applied so as to avoid compression of the underlying skin. The following are descriptions of the location of assessment sites and the procedure used to make the assessment.

Right upper arm. The upper arm was held in a horizontal position parallel to the floor, the elbow flexed and the fist clinched to produce forcible contraction of the biceps. The assessment was made at a point of maximal circumference between the elbow and shoulder.

Chest. The subject abducted the arms at the shoulders and extended the arms in a horizontal position while the tape was placed in position at the nipple level of the breast. The arms were then lowered to the sides and the assessments were taken at the midtidal phase of respiration.

Waist. The assessment was made at the minimal width of the waist, just below the rib cage. This site is approximately midway between the umbilicus and the cartilage of the sternum.

Abdomen. The assessment was made at the site of the iliac crests and the umbilicus. The tape was placed in position at these sites and measurement taken to the nearest tenth of a centimeter.

Hips. The tape was placed in position around the maximal protrusion of the buttocks, and anteriorally the symphysis pubis, and measured to the nearest tenth of a centimeter.

Right thigh. The anthropometric tape was placed in position at the site of the largest measurement of the upper thigh just below crotch level, and measured to the nearest tenth of a centimeter.

Right calf. The assessment was made at the site of maximal circumference and measured to the nearest tenth of a centimeter.

Assessment of Body Composition

The Lange skinfold caliper, with a constant standard pressure of 10 gm/mm^2, was the instrument used for assessing body composition. Body composition, determined by skinfold fat measurements, was assessed prior to and at the conclusion of the ten-weeks progressive resistance exercise program. The skinfold assessment procedures were administered by a competent female professor of physical education at Oklahoma State University who has had previous experience in the use of the Lange skinfold calipers. Two measurements were taken at each site with a third being taken if a discrepancy of more than two millimeters was present in the first two. The two closest readings were averaged and used as the most accurate assessment of skinfold fat at each site.

Brozek and Keys (40) and Pascale et. al (41) were used as references for establishing the proper procedures and site locations for the skinfold assessments in this study. All skinfold measurements were made on the right side of the body. The skinfolds were grasped between the thumb and index finger, the span of the grasp being dependent upon the thickness of the skinfold, with care being taken so as not to include the underlying muscle tissue in the grasp. The Lange skinfold calipers were applied approximately one cm. from the fingers. The skinfold was held loosely while the thickness of the fold was recorded on the calipers.

The sites for the skinfold assessments were: tricep, at the mid-posterior midpoint between the tip of the acromion and the tip of the olecranon with the elbow at 90 degrees flexion, and the subsequent assessment after grasping the skinfold taken with the arm hanging in a straight extended position; subscapular, at the tip of the scapula, the inferior angle, with the subject in a relaxed standing position; iliac, at the lateral crest of the ilium; abdomen, at a point approximately one inch to the right and in a horizontal line with the umbilicus; and thigh, at a point six inches above the upper border of the patella in the vertical midline of the right thigh.

Standardization of Assessment Procedures

Reference was made, in the statement of sub-problems to this study, to the necessity of obtaining reliable assessments from which accurate conclusions may be drawn. A reliability check for each of the assessment procedures, skinfold fat assessments, muscle girth assessments and strength assessments was conducted in order that these measurements would be considered reliable and accurate for drawing conclusions from the results.

After all of the subjects had been assessed and before the progressive resistance exercise program began, ten subjects from the experimental group volunteered to complete the entire testing procedure a second time. Each of the ten subjects was assessed using the exact procedures employed in the initial pre-test of all subjects. A Pearson product-moment correlation technique was used to correlate test and re-test scores of the skinfold fat, muscle girth and strength assessments, thus establishing a correlation coefficient indicative of the reliability of each assessment. The correlation coefficients for the skinfold fat assessments were as follows: tricep, .97; subscapular, .92; abdominal, .98; iliac, .85; thigh, .97. The correlation coefficients for muscle girth assessments were as follows: upper arm, .99; chest, .99; waist, .99; abdomen, .98; hips, .99; thigh, .99; and calf, .99. The correlation coefficients for the strength assessments were as follows: elbow flexion, .98; elbow extension, .96; shoulder adduction, .97; shoulder horizontal adduction, .96; plantar flexion, .95; trunk flexion, .91; knee extension, .95; and knee flexion, .99. From the results of the reliability check, the procedures and the testers proved to have acceptable reliability.

Another sub-problem stated earlier and relating to the standardization of assessment procedures was the up-scale calibration check of the cable tensiometer. This was accomplished by suspending the cable, which was fixed to the attachment strap, from a stabilized bar and progressively adding weight, each time checking the cable tensiometer reading against the actual poundage being suspended. Seven known weights were suspended and checked against the readings on the cable tensiometer and the corresponding conversion chart. The results of this check were considered to be acceptable for assessing human strength in this study.

Progressive Resistance Exercise Program

The progressive resistance exercise program used in this study was designed for female college students who had not previously engaged in any type of progressive resistance exercise programs. The program was designed according to acceptable strength development methods, yet progressive enough in terms of workload and intensity of the work periods to foster motivation to continually improve.

The progressive resistance exercise program was ten weeks in duration with three work sessions per week. The universal gym weight training apparatus was used to perform the progressive resistance exercises. Prior to the beginning of the program the subjects received instruction in the proper methods for using the universal gyms and the basic principles which were to be applied for achieving maximum strength gains. This instruction covered a two-week period which gave each subject ample time to get accustomed to the exercises to be performed and make any necessary adjustments to prepare for the actual program.

Eight basic strength development exercises were used in the program. Illustrations of these exercises are included in Figures 11 through 18. These exercises and the major muscle groups developed through the exercises were as follows: shoulder press (military press), deltoids and triceps; leg press, quadriceps, gluteals, gastrocnemius; bench press, pectorals and triceps; knee extension, quadriceps; knee flexion, hamstrings; arm curl, biceps, forearm masculature; lat-exercisor, latissimus dorsi, upper back musculature; sit-ups, abdominals. The sequence of these exercises were arranged so that no major muscle group would be used consecutively, thus allowing for rest and recovery of a muscle group before continued work, delaying fatigue of that muscle group.

Figure 11. Shoulder Press

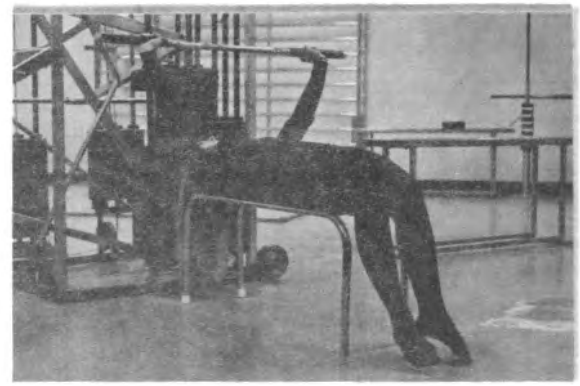

Figure 12. Bench Press

Figure 13. Leg Press

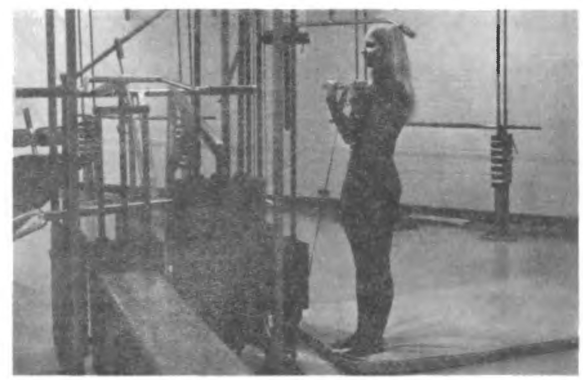

Figure 14. Arm Curl

Figure 15. Pulley Behind Neck

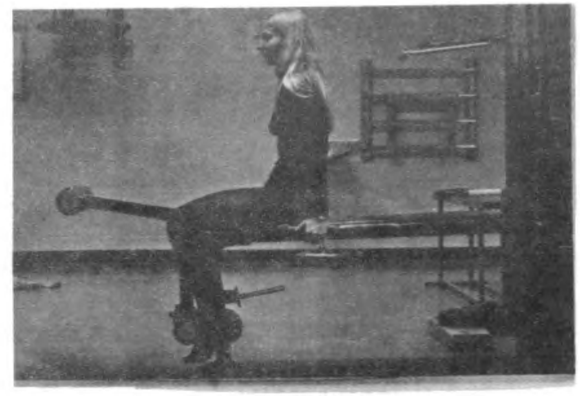

Figure 16. Knee Extension

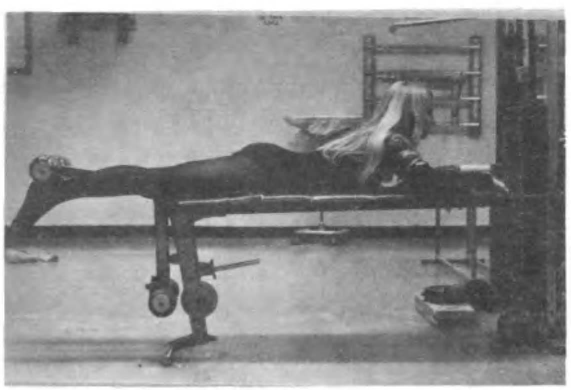

Figure 17. Knee Flexion

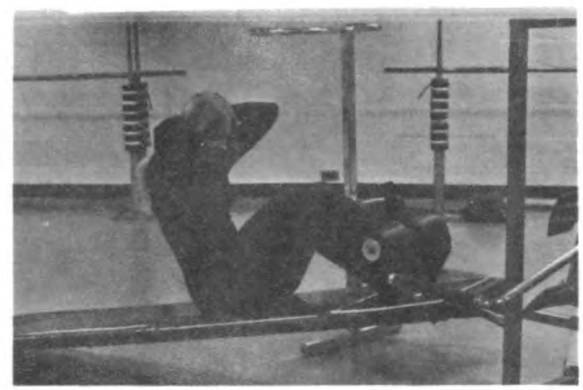

Figure 18. Sit-Up

The work load used throughout the progressive resistance exercise program was the 5-7 RM for each exercise with the exception of sit-ups which were performed according to the strength and endurance of each individual. Each subject established a beginning weight at each exercise station which could be lifted no more than 5-7 times, thus establishing a 5-7 RM for each exercise. The subjects would continue to lift this weight, at each exercise station during the program, until the weight could be lifted ten times. At this point the weight was increased so that a new 5-7 RM was established at that exercise station. This method of establishing a workload was continued throughout the duration of the program.

The intensity of the work period, number of sets performed, was designed to progressively increase the duration of the work period thus progressively increasing the amount of work during a work session as well as progressively increasing the workloads throughout the program. The first two weeks consisted of one set of each exercise at the 5-7 RM, followed by four weeks employing two sets of each exercise at the 5-7 RM, and concluding with four weeks of three sets at the 5-7 RM.

The original progressive resistance exercise program designed for this study was twelve weeks in length, calling for six weeks of three sets at the 5-7 RM as the concluding progression. However, during the eighth week of the program the subjects appeared to be losing their motivation to continually perform maximum exercises over the high intensity session. After discussions with the experimental group it was agreed upon that the program would be shortened to ten weeks, which provided a great deal of motivation to perform maximum efforts on the exercises for the remaining two weeks.

Grouping and Analysis of Data

The previously described assessment procedures were conducted on the experimental and control groups prior to and at the conclusion of the ten-weeks progressive resistance exercise program. The assessment data was analyzed within each group to determine if any significant changes occurred on each assessment item. A t-test was used to test the within group differences thus providing information to accept or reject Hypotheses 1, 2, 4, 5, 7, and 8 stated previously. Analysis of covariance was used to determine if there were any significant differences in post-test scores of the two groups based on adjusted means of the pre-test scores. Thus providing information for the acceptance or rejection of Hypotheses 3, 6, and 9 stated previously. The .05 level of confidence was used as the confidence level for accepting or rejecting the hypotheses. The analysis of the data was carried out by the Oklahoma State University Computer Center using program BMDX 70 designed at the University of California at Los Angeles for the t-tests and the Statistical Analysis System designed at North Carolina State University for the analysis of covariance.

CHAPTER IV

RESULTS

The investigator has attempted to determine the effects of a 10-week program of progressive resistance exercise on the development of strength, muscle girth, and body composition of a group of college women.

Strength Development

Strength was assessed through the use of the cable tensiometer prior to and at the conclusion of the 10 weeks of progressive resistance exercise for both groups of subjects, experimental and control. Table I presents the changes in strength within the experimental and control groups after the experimental group's participation in 10 weeks of progressive resistance exercise. This data includes pre- and post-means recorded in pounds pressure, their corresponding t values and the probability for each t value. The t value indicates the level at which the value can be determined significant in terms of pre- and post-assessment changes in strength within each respective group, experimental and control.

The results of the strength assessments for the control group, as reported in Table I, indicate that there were no appreciable or significant gains in strength except on knee flexion which showed a significant

TABLE I

t TABLE FOR STRENGTH CHANGES WITHIN GROUPS

Test Movement (lbs)		Experimental (N = 32) Means	S.D.	t	p	Control (N = 20) Means	S.D.	t	p
Elbow Flexion	PRE	54.06	7.15	3.02*	.004	54.19	7.87	.42	.67
	POST	59.74	7.87			55.42	10.42		
Elbow Extension	PRE	33.29	5.10	2.76*	.008	32.15	6.78	1.31	.19
	POST	37.29	6.43			34.73	5.68		
Shoulder Adduction	PRE	52.32	9.58	1.91	.06	54.94	10.63	.61	.54
	POST	57.13	10.59			57.09	11.81		
Shoulder Horizontal Adduction	PRE	43.83	10.04	2.61*	.01	46.60	7.76	.29	.77
	POST	50.40	10.13			47.38	8.93		
Plantar Flexion	PRE	135.58	30.30	1.64	.10	134.77	37.96	.72	.47
	POST	148.98	34.82			142.72	31.35		
Trunk Flexion	PRE	52.22	25.08	3.16*	.002	70.99	22.63	-.02	.98
	POST	70.78	21.82			70.81	28.33		
Knee Extension	PRE	133.98	27.51	2.64*	.01	133.72	28.31	.11	.91
	POST	152.67	29.16			134.70	29.20		
Knee Flexion	PRE	57.38	13.45	2.30*	.02	54.76	11.58	2.09*	.04
	POST	64.62	11.72			63.40	14.44		

*t value significant at .05 level.

increase at the .04 level of confidence. There are two possible explanations for this occurrence. Since both the experimental and control groups had similar increases on this particular strength test, the gains may be attributed to a learning factor which may have been present, or to chance variation, since this was the only significant change recorded for the control group in the three assessment areas of strength, muscle girth, and body composition.

The results of the strength assessments for the experimental group, as reported in Table I, reveal gains in strength on all tests with six of the eight gains being significant beyond .05 level of confidence. Strength increases for elbow flexion, elbow extension, shoulder horizontal adduction, trunk flexion, and knee extension were significant at the .01 level of confidence, while the increase for knee flexion was significant at the .02 level. Strength values for shoulder adduction and plantar flexion increased but did not show statistically significant changes.

Table II presents the strength gain comparisons for the experimental and control groups after the 10 weeks of progressive resistance exercise. Analysis of covariance was used to determine the differences between the two groups, using the pre-mean as the covariate to establish the adjusted means. Included in this table are the pre- and post-means for strength, the adjusted means, their corresponding F ratio and the probability for each F ratio. The F ratio indicates the level at which the value can be determined significant in terms of strength differences between the two groups.

The results reported in Table II reveal that the experimental group showed statistically significant increases in strength over the control group at the .01 level of confidence for elbow flexion, shoulder

TABLE II

ANOCV: STRENGTH GAIN COMPARISONS BETWEEN GROUPS

Test Movement (lbs)	Group	Pre-Mean	S.D.	Post-Mean	S.D.	Adjusted Mean	F Ratio	P
Elbow Flexion	E	54.06	7.15	59.74	7.87	59.78	6.40*	.01
	C	54.19	7.87	55.42	10.42	55.36		
Elbow Extension	E	33.29	5.10	37.29	6.43	37.02	1.66	.20
	C	32.15	6.78	34.73	5.68	35.18		
Shoulder Adduction	E	52.32	9.58	57.13	10.59	58.04	1.61	.21
	C	54.94	10.63	57.09	11.81	55.65		
Shoulder Horizontal Adduction	E	43.83	10.64	50.40	10.13	51.36	14.71*	.0004
	C	46.60	7.76	47.38	8.93	45.85		
Plantar Flexion	E	135.58	30.30	148.98	34.82	148.75	.78	.38
	C	134.77	37.96	142.72	31.35	143.09		
Trunk Flexion	E	52.22	25.08	70.78	21.82	74.47	2.15	.15
	C	70.99	22.63	70.81	28.33	64.90		
Knee Extension	E	133.98	27.51	152.67	29.16	152.59	10.93*	.001
	C	133.72	28.31	134.70	29.20	134.83		
Knee Flexion	E	57.38	13.45	64.62	11.72	63.91	.05	.81
	C	54.76	11.58	63.40	14.44	64.54		

E = Experimental Group (N = 32).

C = Control Group (N = 20)

*F Ratio Significant at .05 level.

horizontal adduction and knee extension. Although appreciable strength gains were evidenced within the experimental group, the remaining test movements revealed no significant increases for the experimental group when compared to the control group.

The elbow flexion, shoulder horizontal adduction, and knee extension strength tests resulted in significant increases for the experimental group over the control group. These increases indicate the effects of the arm curl, bench press, and leg press exercises in the program which are similar movements to the strength test items. In the most recent studies by Wilmore (5), Brown and Wilmore (4), and Mayhew and Gross (37), performance on the bench press, arm curl, and leg press were used as indicators of strength improvement, and each study reported significant strength gains for these exercises. The significant increases for the three strength tests found in this study thus correspond to the significant increases in strength reported in these studies (4) (5) (37).

Muscle Girth Changes

Muscle girth assessments were taken on both the experimental and control groups prior to and at the conclusion of the 10 weeks of progressive resistance exercise. The results of these muscle girth assessments are presented in Table III and Table IV.

Table III presents the muscle girth changes within each group, experimental and control, following the 10 weeks of progressive resistance exercise. Included in this table are the pre- and post-means for muscle girth assessment, their corresponding t values, and the

TABLE III

t TABLE FOR STRENGTH CHANGES WITHIN GROUPS

Muscle Girth Sites (cm)		Experimental				Control			
		Means	S.D.	t	p	Means	S.D.	t	p
Upper Arm	PRE	26.26	1.75	2.05*	.04	26.01	1.63	1.51	.14
	POST	27.16	1.76			26.78	1.61		
Chest	PRE	84.96	6.79	-1.13	.26	83.08	6.08	-.31	.75
	POST	83.22	5.46			82.54	4.61		
Waist	PRE	66.33	5.50	-.67	.50	64.78	4.59	.18	.86
	POST	65.47	4.85			65.06	5.15		
Abdomen	PRE	71.19	5.83	1.08	.28	72.34	5.09	.26	.79
	POST	72.71	5.45			72.82	6.30		
Hips	PRE	93.15	5.41	-.38	.71	92.15	5.36	.28	.78
	POST	92.66	4.99			92.64	5.46		
Thigh	PRE	55.09	4.32	.05	.96	54.01	6.28	.92	.36
	POST	55.14	3.96			55.53	3.94		
Calf	PRE	35.16	5.42	-1.65	.10	33.58	2.23	.84	.40
	POST	32.71	6.40			34.17	2.20		

*t value significant at .05 level.

TABLE IV

ANOCV: MUSCLE GIRTH COMPARISONS BETWEEN GROUPS

Muscle Girth Sites (cm)	Group	Pre-Mean	S.D.	Post Mean	S.D.	Adjusted Mean	F Ratio	p
Upper Arm	E	26.26	1.75	27.16	1.76	27.07	.58	.45
	C	26.01	1.63	26.78	1.61	26.93		
Chest	E	84.96	6.79	83.22	5.46	82.74	.45	.51
	C	83.08	6.08	82.54	4.61	83.30		
Waist	E	66.33	5.50	65.47	4.85	64.92	3.39	.07
	C	64.78	4.59	65.06	5.15	65.91		
Abdomen	E	71.19	5.83	72.71	5.45	73.11	1.13	.29
	C	72.34	5.09	72.82	6.30	72.19		
Hips	E	93.15	5.41	92.66	4.99	92.31	3.37	.07
	C	92.15	5.36	92.64	5.46	93.19		
Thigh	E	55.09	4.32	55.14	3.96	54.89	1.99	.16
	C	54.01	6.28	55.53	3.94	55.93		
Calf	E	35.16	5.42	32.71	6.40	33.60	1.89	.17
	C	33.58	2.23	34.17	2.20	34.42		

E = Experimental Group

C = Control Group

*F ratio significant at .05 level.

probability level for the t values which indicate at what level the girth changes are statistically significant.

The results reported in Table III reveal no significant girth changes in either the control group or the experimental group with the exception of the upper arm girth of the experimental group. The muscle girth assessments for the upper arm in the experimental group showed a statistically significant increase in girth at the .04 level of confidence. This increase represents .9 cm which is a relatively small increase in circumference girth. However, this increase corresponds to the reported upper arm girth increases reported in similar studies by Wilmore (5), Brown and Wilmore (4), and Mayhew and Gross (37).

Table IV presents the muscle girth comparisons between the experimental and control groups after the 10 weeks of progressive resistance exercise. The pre- and post-mean girth assessments, their corresponding F ratios and the probability levels for both groups are included in the table.

There were no significant girth changes for the experimental group when compared to the control group as a result of the 10 weeks of progressive resistance exercise. Since there was no significant differences in upper arm girth assessments when the two groups were compared, these results tend to negate the significant increase in upper arm girth which occurred within the experimental group.

The results from the muscle girth assessments correspond with the reported findings in previous studies by Wilmore (5), Brown and Wilmore (4), and Mayhew and Gross (37) which indicated significant upper arm girth increases, but revealed no significant increases in the remaining circumference assessment sites. The results from the assessments taken in this study further dispute the common belief that women are apt to develop large "bulky muscles" as a result of vigorous, heavy resistance exercise.

Body Composition Changes

Skinfold fat assessments were made prior to and at the conclusion of the 10 weeks of progressive resistance exercise in an effort to determine the effects of the program on body composition.

Table V presents the skinfold thickness changes within each of the two groups, experimental and control, after the 10 weeks of progressive resistance exercise. The pre- and post-means for skinfold thickness, their corresponding t values and the probability levels for each value are included in the table.

Table VI presents skinfold thickness comparisons between the two groups after the 10 weeks of progressive resistance exercise. Included in this table are the pre- and post-means for skinfold thickness, the adjusted means, their corresponding F ratios and the probability level for each ratio.

The results in Table V reveal no significant skinfold thickness changes within either group, experimental or control. Likewise, in Table VI, the experimental group showed no significant skinfold thickness changes when compared to the control group.

From the results of the skinfold thickness assessments, there was no evidence of significant body composition change. In previous studies of similar design, Wilmore (5), Brown and Wilmore (4), and Mayhew and Gross (37), skinfold thickness was used as an indicator of body

TABLE V

t TABLE FOR SKINFOLD THICKNESSES WITHIN GROUPS

Skinfold Site (mm)		Experimental Means	Experimental S.D.	Experimental t	Experimental p	Control Means	Control S.D.	Control t	Control p
Tricep	PRE	19.92	4.60	1.23	.22	19.81	4.71	.20	.84
	POST	21.44	5.25			20.14	5.57		
Subscapular	PRE	15.59	5.97	1.92	.06	16.29	5.59	1.19	.24
	POST	18.58	6.45			18.50	6.18		
Iliac	PRE	25.56	7.81	-.26	.79	23.61	6.94	-.08	.93
	POST	25.06	7.56			23.41	7.93		
Abdominal	PRE	25.98	8.86	1.30	.19	28.31	8.49	.52	.60
	POST	28.79	8.37			29.91	10.70		
Thigh	PRE	30.31	6.76	.31	.75	31.45	6.17	.42	.69
	POST	30.87	7.45			32.30	6.70		

*t value significant at .05 level.

TABLE VI

ANOCV: SKINFOLD THICKNESS COMPARISONS BETWEEN GROUPS

Skinfold Site (mm)	Group	Pre-Mean	S.D.	Post-Mean	S.D.	Adjusted Mean	F Ratio	p
Tricep	E	19.92	4.60	21.44	5.25	21.39	1.79	.19
	C	19.81	4.71	20.14	5.57	20.20		
Subscapular	E	15.59	5.97	18.58	6.45	18.81	.41	.52
	C	16.29	5.59	18.50	6.18	18.12		
Iliac	E	25.56	7.81	25.06	7.56	24.37	.02	.87
	C	23.61	6.94	23.41	7.93	24.52		
Abdominal	E	25.98	8.86	28.79	8.37	29.57	.27	.60
	C	28.31	8.49	29.91	10.70	28.69		
Thigh	E	30.31	6.76	30.87	7.45	31.26	.12	.73
	C	31.45	6.17	32.30	6.70	31.68		

E = Experimental Group

C = Control Group

*F ratio significant at .05 level.

composition. However, only the study by Wilmore (5) reported significant body composition changes as measured by skinfold thickness. A logical assumption is that if strength is significantly increased through resistance exercise then increased size of the myofibrils of the muscle will result, thus increasing muscle size, or lean body mass. Through the use of additional measures of body composition, the previously mentioned studies have substantiated the fact that lean body mass increases, and there is a corresponding loss in adipose tissue in the female as a result of heavy resistance exercise. Brown and Wilmore (4) offered an explanation as to the lack of detection of body composition change through skinfold thickness techniques. Their explanation was that as body composition changed, with increasing lean body mass and reduction in adipose tissue, skinfold thickness may increase due to the development of tissue laxity at the measurement sites.

The results of the skinfold thickness assessments revealed very little about the actual changes in body composition of the women in this study. However, the results may reveal something about the method of determining body composition change in a study of this design. The results from the skinfold assessments in this study, as well as the reported results from previous similar studies (4) (5) (37), raises a question concerning the skinfold thickness technique as an accurate assessment of actual change in body composition. Methods of evaluating body composition change which have proved to be more effective include hydrostatic weighing techniques (42), and whole body ^{40}K scintillation (43).

Summary and Discussion of Results

Fifty-two college women, 32 participating in the experimental group and 20 serving as control subjects, were assessed for strength, muscle girth and skinfold thickness. These assessments were made prior to and at the conclusion of the experimental group's participation in 10 weeks of progressive resistance exercise. This was done in an effort to determine the effects of the progressive resistance exercise program on each of the assessment areas.

Strength was assessed by using eight cable tension strength tests, designed for this particular study, in order to determine strength changes which occurred as a result of the progressive resistance exercise program.

Knee flexion revealed a significant increase within the control group which was attributed to a learning factor and/or chance variation. The remaining tests showed no significant strength changes within the control group. The experimental group, which participated in the 10 weeks of progressive resistance exercise, showed appreciable strength gains on all eight strength tests with six of the eight being statistically significant. The results of the analysis of covariance, which compared strength changes of the two groups based on adjusted means, revealed significant strength gains for the experimental group as compared to the control group on elbow flexion, shoulder horizontal adduction, and knee extension.

Muscle girth was measured at seven sites on all subjects before and after the program of progressive resistance exercise. The results of these assessments revealed no significant muscle girth changes within either the experimental or control group with the exception of upper arm girth in the experimental group. The results of upper arm girth changes in the experimental group revealed an increase of .9 cm which was statistically significant; however, the increase was noted as being a relatively small circumferential gain. The results of the analysis of covariance revealed no significant muscle girth changes for the experimental group when compared to the control group. This contributes supporting evidence to previous studies (4) (5) (37) which dispute the common belief that vigorous, heavy resistance exercise will result in large "bulky muscles" in the female. In the studies by Wilmore (5) and Brown and Wilmore (4), a probable theoretical explanation was given as to why the male develops muscle bulk as a result of heavy resistance exercise and the female does not. Their theory was based on investigations (44) (45) (46) suggesting that the predominantly male hormone, testosterone, dictates the increase in body size and muscle bulk. Contributing evidence for their theoretical explanation was also cited in studies (47)(48), which established the fact that testosterone production rates and plasma levels are 20 to 30 times higher in males than females. Thus, they theorized that the female has the same potential for strength development as the male of comparable size; however, due to the vast higher levels of testosterone in the male, the female will not respond to heavy resistance exercise in terms of muscle bulk as will the male.

Five skinfold thickness assessments were made with Lange skinfold calipers on all subjects prior to and at the conclusion of the progressive resistance exercise program, in an effort to determine body composition changes. The results from these assessments revealed no significant skinfold changes within either group nor when the two groups were compared using analysis of covariance. The skinfold thickness results in this study were compared to results in previous studies (4) (5) (37) and it was noted that only one revealed any significant body composition changes using the skinfold thickness method of assessment. The results of the skinfold thickness assessments in this study are comparable to the results reported by Brown and Wilmore (4) and Mayhew and Gross (37) in that the skinfold thickness assessments revealed no significant changes indicating no change in body composition.

In essence, the results of this study revealed: significant strength improvement within the experimental group on six of the eight strength tests; no significant strength changes with the exception of knee flexion within the control group; and significant strength improvement in elbow flexion, shoulder horizontal adduction, and knee extension for the experimental group when compared to the control group. In terms of muscle girth assessments the results revealed: no significant changes within the experimental group with the exception of upper arm girth which significantly increased, no significant changes within the control group, and no significant differences in strength when the experimental group was compared to the control group. The results of the skinfold assessments revealed no significant changes within either the experimental or control group and revealed no significant differences in skinfold thickness when the two groups were compared.

The use of heavy resistance exercise has not been considered to be an acceptable form of exercise by the vast majority of the female population due to the fear of resulting masculinizing effects. Since the subjects who participated in this study were from a population of college females who had not seriously considered the use of heavy resistance exercise prior to this study, the obtaining of their attitudes and opinions concerning their participation, motivation, and derived benefits was considered to be a worthwhile endeavor. Therefore, at the conclusion of the 10 weeks of progressive resistance exercise, the experimental group was asked to fill out an informal questionnaire pertaining to: their attitudes and opinions about female participation in this program of resistance exercise, their motivation to continue with the program, and benefits they feel they gained from the program.

The initial reaction, when introduced to the experimental study, was one of mixed excitement and apprehension. Approximately 50% of the subjects expressed apprehension at the outset of the experiment about the appearance of their figure becoming more masculine in appearance. However, as the program progressed, the subjects expressed very little apprehension about this study producing any masculine effects. When asked if they would recommend weight training to female friends and if they would continue to use weight training in the future if facilities were available, 75% responded affirmatively. However, the fear of developing masculine features was not completely overcome. Five subjects expressed apprehension about prolonged use of weight training, nine were still uncertain and eighteen were convinced that it would produce no masculine effects.

The use of heavy resistance exercise, whether by male or female, is dependent upon a high degree of motivation to accomplish specific results. This was evident in this study. Eight of the 32 experimental subjects expressed a relatively high degree of motivation to continue the program at the eighth week of the proposed twelve-week study. The remaining 24 subjects expressed a relatively low level of motivation to continue. The results from this questionnaire, concerning the degree of motivation present during the eighth week of the study, substantiates the feelings of the investigator that during the eighth week the subjects were becoming less motivated to continue through a twelve-week program. This decline in motivation was indicative of the need to shorten the program to ten weeks instead of the proposed twelve weeks.

The experimental subjects expressed the opinion that the benefits derived from the program were quite obvious. Thirty-one of the 32 subjects expressed the feeling that they were definitely stronger, and that the benefits were evidenced through general feelings of better health and improved muscle tonus.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine the effects of a 10-week progressive resistance exercise program on the development of strength, muscle girth, and body composition of college women. Fifty-two college women, 32 experimental subjects and 20 control subjects, were assessed for strength, muscle girth, and skinfold thickness. Eight cable tension strength tests were administered to each subject to determine muscular strength. Seven muscle girth sites were assessed for each subject using a Lufikin anthropometric tape. Five skinfold thicknesses were taken as an indicator of body composition for each subject. After all of the subjects had been assessed for strength, muscle girth, and body composition, a progressive resistance exercise program employing the universal gym weight training apparatus was initiated for the experimental subjects. The duration of the program was ten weeks and consisted of eight basic strength development exercises. The workloads and intensities of the work periods were as follows: two weeks performing one set of the 5-7 RM, four weeks performing two sets of the 5-7 RM, and four weeks performing three sets of the 5-7 RM. At the conclusion of the 10-week progressive resistance exercise program, the exact procedures used previously for assessing strength, muscle girth, and body composition were administered again for each subject, experimental and control.

Conclusions

Within the limits of this study and based on the previously stated hypotheses, using the .05 level as the rejection criterion, the following conclusions were made.

1. There will be no significant difference in strength in the experimental group from pre-test to post-test on the following strength assessments: elbow flexion, elbow extension, shoulder adduction, shoulder horizontal adduction, plantar flexion, knee flexion, knee extension, trunk flexion.

Hypothesis One was rejected for the strength tests of elbow flexion, elbow extension, shoulder horizontal adduction, knee flexion, knee extension and trunk flexion. It was accepted for the strength tests of should adduction and plantar flexion.

2. There will be no significant difference in any of the strength assessments in the control group from pre-test to post-test.

Hypothesis Two was accepted on all of the strength tests with the exception of knee flexion. The hypothesis statement concerning knee flexion was rejected.

3. There will be no significant difference in strength between the post-test scores of the experimental and control groups on the following strength assessments: elbow flexion, elbow extension, shoulder adduction, shoulder horizontal adduction, plantar flexion, knee flexion, knee extension, trunk flexion.

Hypothesis Three was accepted for elbow extension, shoulder adduction, plantar flexion, knee flexion, and trunk flexion. It was rejected for elbow flexion, shoulder horizontal adduction, and knee extension.

4. There will be no significant difference in muscle girth in the experimental group from pre-test to post-test on the following girth measurements: chest, waist, abdomen, hips, thigh, calf, upper arm.

This hypothesis was accepted for all muscle girth assessments with the exception of the upper arm girth. The hypothesis was rejected for upper arm girth.

5. There will be no significant difference in any of the muscle girth assessments in the control group from pre-test to post-test.

Hypothesis Five was accepted for all muscle girth assessments within the control group.

6. There will be no significant difference in muscle girth between the post-test scores of the experimental and control groups on the following girth assessments: chest, waist, abdomen, hips, thigh, calf, upper arm.

Hypothesis Six was accepted for all muscle girth comparisons between the two groups.

7. There will be no significant difference in skinfold fat measurements in the experimental group from pre-test to post-test at the following sites: tricep, subscapular, abdominal, iliac, thigh.

Hypothesis Seven was accepted for all skinfold fat measurements within the experimental group.

8. There will be no significant difference in any of the skinfold fat measurements in the control group from pre-test to post-test.

Hypothesis Eight was accepted for all skinfold fat measurements within the control group.

9. There will be no significant difference in skinfold fat measurements between the post-test scores of the experimental group and control group at the following sites: tricep, subscapular, abdominal, iliac, thigh.

Hypothesis Nine was accepted for all skinfold fat comparisons between the two groups.

From the results of this study, it was concluded that progressive resistance exercise over a ten-week period using a workload of 5-7 RM produced significant strength gains in college females. It was also concluded that no significant muscle girth or body composition changes occurred as a result of the described program.

Recommendations

The study of heavy resistance exercise and its effects upon the female is a relatively new area of research. In order that factual knowledge concerning the effects of heavy resistance exercise on the female may be established, more research in this area is necessary.

It may be that studies extending for prolonged periods of time, six months to one year, may be necessary in order to more accurately assess the effects of heavy resistance exercise on the female's body composition and physique alterations.

In studies similar to this one, more precise methods of detecting body composition changes, such as hydrostatic weighing or whole body ^{40}K scintillation, should be used in addition to or in lieu of skinfold thickness assessments.

The extended use of heavy resistance weight training requires a great deal of motivation in order to accomplish specific goals of strength development, endurance, and/or physique alterations. In order for females to maintain the motivation necessary to accomplish specific goals, it appears that the most attractive method may be a combination of activities. Such a combination might consist of weight training for strength or endurance in conjunction with vigorous activities designed for cardiovascular endurance such as running, swimming, or cycling.

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APPENDIX

TABLE VII

SKINFOLD THICKNESS DATA (mm)

Subject Number	Tricep pre	Tricep post	Subscapular pre	Subscapular post	Abdomen pre	Abdomen post	Iliac pre	Iliac post	Thigh pre	Thigh post
Control										
1	23.50	32.50	16.75	31.00	33.00	37.00	44.5	50.75	43.50	46.75
2	26.50	26.50	19.50	18.50	29.00	26.50	34.75	40.25	39.00	38.00
3	15.75	14.25	14.75	11.50	15.25	17.50	28.75	17.50	25.50	23.50
4	21.75	22.25	34.50	33.25	38.25	41.00	44.75	43.00	34.75	34.75
5	22.00	25.75	20.50	22.75	26.25	23.75	33.75	43.25	36.00	36.50
6	16.75	16.00	13.25	16.00	15.50	13.25	16.75	19.50	27.50	25.50
7	13.00	14.25	8.50	7.50	19.00	18.25	23.00	20.75	20.00	19.00
8	21.00	18.75	12.00	17.25	15.75	13.00	17.00	15.75	31.50	30.50
9	19.50	22.00	9.50	16.25	14.50	21.75	15.00	18.00	27.00	35.25
10	21.00	17.75	18.25	17.00	26.25	28.25	36.00	31.50	22.00	23.25
11	29.25	26.75	16.00	14.50	25.00	25.25	33.00	34.75	41.75	40.25
12	20.00	19.50	17.00	15.25	25.50	25.25	28.00	33.75	31.00	33.50
13	19.50	19.00	19.50	22.50	25.00	19.50	34.75	30.25	36.25	33.00
14	18.00	16.75	17.50	18.75	27.50	25.75	26.75	28.00	26.00	23.00
15	21.00	18.00	12.25	14.00	16.50	10.00	21.00	16.50	36.25	37.75
16	12.50	11.50	12.00	15.50	22.00	19.25	23.75	25.75	28.75	32.00
17	23.25	23.00	15.50	17.25	29.75	31.00	28.75	33.00	31.75	35.00
18	17.25	17.75	16.00	18.50	28.50	29.75	25.00	42.25	31.00	34.50
19	10.25	12.75	11.50	16.00	12.75	15.75	19.50	17.50	28.75	32.75
20	24.50	27.75	21.00	26.75	27.00	26.50	31.50	36.25	30.75	31.25
Experimental										
21	26.75	31.25	12.25	20.25	27.25	31.00	27.75	33.50	39.00	43.50
22	19.50	17.50	12.00	14.50	18.50	22.25	14.75	22.25	31.00	34.25
23	11.75	14.00	8.50	18.00	6.50	10.00	11.75	19.00	19.00	26.25
24	19.75	24.00	14.75	15.50	29.50	30.25	37.50	34.50	27.25	27.25
25	27.75	26.95	26.00	25.45	33.75	30.75	35.00	34.45	39.50	37.55
26	18.50	20.00	10.50	14.75	20.00	16.00	22.50	26.25	32.50	31.75
27	15.75	15.75	12.00	10.75	18.00	19.00	18.00	17.50	27.75	26.00
28	19.50	16.75	15.25	16.50	19.50	20.25	25.25	29.25	35.00	23.50
29	18.00	16.25	14.00	13.75	29.25	27.25	32.25	24.25	29.75	25.75
30	17.75	20.50	17.25	19.75	29.00	29.00	20.75	24.50	28.50	30.00
31	9.25	9.50	7.00	6.75	20.25	15.00	15.00	13.50	16.75	13.75
32	19.00	22.75	11.50	13.75	22.50	20.00	22.25	20.00	33.50	30.50
33	21.50	24.00	19.00	19.50	24.75	31.50	30.00	35.50	29.50	34.50
34	15.50	13.75	8.75	12.75	14.50	11.75	14.25	15.75	22.00	20.75
35	20.50	19.00	13.00	10.75	23.00	18.00	31.25	30.50	20.50	19.75
36	22.00	24.00	9.25	9.50	23.00	19.50	27.25	22.50	31.75	30.75
37	13.50	14.75	11.00	13.00	15.00	16.50	11.75	15.25	15.50	18.25
38	30.00	30.25	27.00	32.00	40.25	31.75	43.00	40.75	39.00	32.25
39	26.25	25.00	23.25	20.00	35.25	29.50	34.50	38.00	30.50	23.25
40	16.50	20.50	11.75	18.25	26.00	25.00	21.00	24.75	26.00	30.75
41	17.75	19.00	11.00	16.50	23.25	25.00	22.00	26.50	29.00	35.00
42	17.00	20.00	18.00	20.75	25.00	27.50	34.00	34.50	32.75	33.00
43	22.25	19.75	19.25	20.75	21.00	19.50	24.25	31.50	39.25	36.50
44	20.25	26.00	22.50	21.75	29.25	25.50	32.75	28.00	36.75	38.00
45	22.00	28.50	19.25	22.25	31.50	34.00	25.00	34.00	30.50	44.50
46	24.00	26.00	30.00	35.75	39.00	40.75	40.75	43.25	42.75	43.50
47	15.00	20.50	11.50	22.25	19.00	23.00	13.75	25.00	21.25	25.75
48	19.00	26.75	10.00	19.25	21.75	24.25	16.50	36.75	32.00	37.00
49	24.50	28.50	23.25	30.50	40.25	40.25	38.25	45.50	35.25	38.25
50	20.50	24.25	13.25	21.50	30.50	31.50	26.75	36.00	31.00	37.00
51	20.75	22.75	21.50	24.25	35.25	33.50	36.00	35.75	34.00	31.25
52	25.50	17.50	15.25	13.50	26.50	23.00	25.75	22.75	31.25	27.75

TABLE VIII

MUSCLE GIRTH DATA (cm)

Subject	Upper Arm		Chest		Waist		Abdomen		Hips		Thigh		Calf	
Number	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
Control														
1	26.55	29.60	82.15	88.40	69.35	74.60	79.95	86.35	97.75	102.05	57.25	61.40	34.00	35.95
2	28.10	28.85	92.75	86.20	71.20	70.35	81.40	81.90	95.55	96.10	59.15	59.20	35.75	36.45
3	24.50	25.05	78.60	80.05	60.30	60.05	69.98	66.15	84.00	82.65	48.50	48.70	29.80	28.85
4	26.65	27.70	96.95	86.60	74.95	77.15	78.25	82.25	99.95	101.35	60.10	62.80	35.25	36.50
5	26.30	26.80	77.00	76.45	60.70	60.75	68.65	66.35	88.65	88.65	53.95	54.20	33.35	33.55
6	25.50	25.90	78.65	78.35	59.35	59.55	67.80	67.85	87.98	89.00	51.55	52.85	32.20	32.70
7	23.35	24.05	74.20	74.50	60.60	61.60	68.90	68.05	89.65	90.05	53.60	53.60	30.35	31.05
8	24.35	25.95	81.80	82.00	62.40	61.10	65.50	67.85	92.55	91.75	54.20	56.05	35.45	36.10
9	25.80	26.60	76.35	78.45	59.90	60.75	63.50	65.10	85.30	87.65	48.85	51.10	31.20	32.05
10	28.50	29.70	87.10	90.00	68.15	69.50	76.40	75.00	93.35	95.75	34.15	55.75	33.95	35.20
11	28.85	28.85	88.65	86.05	67.55	65.30	79.00	76.25	98.90	97.80	60.55	58.40	38.25	37.55
12	27.45	27.65	87.90	86.25	71.30	71.40	75.50	78.00	99.50	99.55	64.15	62.55	36.85	36.35
13	25.95	26.15	84.15	83.20	61.85	60.70	72.50	67.55	95.30	93.35	57.35	54.65	32.85	32.15
14	25.60	26.45	81.10	81.25	64.40	64.60	74.75	74.75	88.15	88.95	50.60	51.80	32.25	34.35
15	26.45	26.25	82.10	79.35	63.90	62.25	68.85	69.30	96.30	93.20	57.45	55.90	35.30	34.70
16	25.60	25.90	84.25	82.10	63.40	61.15	73.50	71.55	91.70	91.20	56.20	55.45	33.80	35.55
17	25.25	26.50	76.85	70.60	61.90	64.65	68.15	70.25	88.60	91.30	53.00	54.25	31.45	33.10
18	25.30	25.80	83.90	84.30	64.90	64.35	71.25	72.90	86.60	87.35	52.95	53.90	32.15	32.60
19	22.55	24.10	76.60	78.10	60.25	63.05	67.60	68.15	84.45	85.55	49.55	49.95	31.95	33.30
20	27.65	27.85	90.50	90.60	69.25	68.35	75.55	80.90	98.90	99.40	57.20	58.20	35.50	35.35
Experimental														
21	26.60	27.05	82.05	79.67	63.97	64.37	71.35	70.60	89.40	89.95	55.45	56.25	32.15	31.55
22	24.55	25.10	77.95	75.90	62.55	60.80	64.40	65.10	89.90	88.30	49.80	50.55	30.60	30.35
23	23.75	25.25	76.10	78.45	57.10	59.85	62.10	63.40	82.70	86.30	47.90	49.80	29.15	30.05
24	26.60	27.30	91.80	90.65	66.37	66.90	72.65	72.10	92.35	93.05	57.25	56.15	36.85	36.05
25	28.15	28.47	95.95	91.57	72.55	68.75	76.85	73.85	100.75	95.20	63.00	58.85	37.65	37.00
26	26.25	27.60	90.20	87.95	70.90	68.55	74.85	75.20	100.30	100.20	58.75	58.57	36.30	36.50
27	25.75	26.85	86.85	84.15	67.75	66.65	71.00	73.90	92.70	91.80	54.20	54.25	35.40	34.40
28	26.10	26.90	77.45	82.10	61.90	63.30	68.85	69.70	91.85	94.05	54.20	56.90	32.90	33.20
29	24.70	25.30	80.17	75.60	64.70	61.70	70.85	70.15	88.50	87.45	50.00	49.95	29.30	29.55
30	25.00	25.90	75.70	77.20	63.30	62.60	67.10	71.75	90.35	90.20	51.35	52.85	31.00	31.10
31	23.05	23.50	78.45	77.00	58.65	58.10	61.35	70.65	84.80	83.95	48.60	48.00	31.25	31.70
32	25.60	26.10	78.60	78.20	63.50	61.00	66.10	66.05	90.30	89.75	52.15	50.10	33.75	32.80
33	26.60	26.80	81.60	82.20	66.60	66.10	74.15	78.65	95.50	96.70	57.55	58.15	35.35	34.75
34	24.65	26.25	85.20	83.80	59.85	57.20	65.70	62.05	84.70	83.10	51.55	51.45	31.95	31.15
35	25.25	25.00	79.60	77.65	64.80	62.35	71.40	70.35	89.05	86.55	54.55	52.60	33.15	32.35
36	26.50	27.40	77.60	76.95	66.35	66.60	73.70	72.05	92.40	92.90	56.00	56.45	35.80	36.50
37	25.15	27.15	82.40	82.55	66.40	65.40	68.05	68.95	89.40	88.90	49.55	50.25	31.30	31.00
38	29.60	31.10	96.85	94.70	82.55	79.30	85.40	88.65	105.05	102.60	60.15	60.60	35.80	35.85
39	27.90	29.90	97.60	82.30	74.50	71.30	78.90	77.95	98.75	97.45	62.90	61.20	38.95	38.30
40	25.85	25.80	82.80	82.30	63.90	63.75	66.30	69.75	89.75	88.30	53.20	52.50	53.80	33.45
41	25.80	26.35	82.95	80.50	62.60	60.95	69.30	73.00	93.35	92.25	51.85	51.35	35.60	35.65
42	27.00	27.65	91.50	88.80	67.25	64.90	71.65	70.85	99.75	99.45	61.75	61.50	34.15	34.30
43	26.60	28.00	85.80	84.10	64.25	63.15	68.55	69.30	92.55	91.10	53.30	54.05	33.50	33.35
44	25.95	27.75	96.15	89.55	75.75	72.05	82.96	78.65	103.25	100.50	62.45	61.00	37.10	36.65
45	26.15	27.25	81.20	83.05	66.55	68.85	72.00	78.45	97.35	99.25	57.15	60.00	31.85	32.35
46	30.65	31.60	96.55	97.50	76.30	74.45	79.40	80.15	98.00	97.45	58.95	59.50	34.90	35.10
47	25.20	26.05	83.10	82.95	60.40	61.55	64.70	70.30	87.85	88.70	50.40	51.10	31.78	31.30
48	28.30	28.65	79.40	82.40	63.70	61.30	66.10	70.95	91.45	90.65	57.25	56.00	36.15	35.60
49	29.80	29.95	91.25	81.25	72.05	70.70	75.15	79.20	99.00	97.05	59.20	58.95	37.10	36.35
50	23.45	25.50	81.10	79.50	63.90	66.20	70.25	75.00	93.25	95.10	52.15	53.85	33.90	33.85
51	27.40	27.85	90.65	86.95	67.35	69.85	79.85	79.00	93.60	93.30	56.00	56.75	33.40	34.25
52	26.60	28.00	84.20	85.55	64.25	66.10	67.05	71.05	91.75	93.75	53.85	54.90	53.30	33.60

TABLE IX

STRENGTH TEST DATA (lbs. press.)

Subject Number	Elbow Flexion		Elbow Extension		Shoulder Adduction		Shoulder Horiz. Add.		Plantar Flexion		Trunk Flexion		Knee Extension		Knee Flexion	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
Control																
1	40.0	35.0	28.3	26.6	36.6	38.3	32.4	26.6	100.0	110.0	40.0	38.3	67.5	106.0	36.6	36.6
2	65.0	67.5	33.5	28.3	55.0	60.0	48.3	52.5	186.5	200.0	112.5	135.0	135.0	163.0	52.5	75.0
3	50.0	41.5	41.5	38.3	60.0	72.5	46.5	46.5	112.5	112.5	72.5	122.5	100.0	87.5	52.5	52.5
4	58.3	55.0	30.0	32.4	50.0	50.0	46.5	52.5	104.0	100.0	92.5	58.3	108.0	106.0	45.0	48.3
5	45.0	58.3	25.0	38.3	55.0	61.6	40.0	40.0	85.0	140.0	65.0	57.5	115.0	137.5	67.5	80.0
6	52.5	61.6	38.3	40.0	52.5	55.0	45.0	45.0	160.0	132.5	77.5	60.0	143.0	146.5	61.6	72.5
7	43.2	41.5	28.3	36.6	38.3	38.3	38.3	36.6	143.0	117.5	82.5	52.5	135.0	117.5	60.0	48.3
8	55.0	57.5	35.0	33.5	46.5	63.3	45.0	48.3	170.0	186.5	92.5	115.0	150.0	150.0	60.0	80.0
9	57.5	58.3	30.0	28.3	63.3	61.6	43.2	48.3	102.0	130.0	58.3	61.6	115.0	137.5	38.3	46.5
10	70.0	77.5	52.5	48.3	75.0	87.5	61.6	65.0	153.0	143.0	70.0	58.3	166.5	153.0	60.0	72.5
11	48.3	48.3	30.0	33.5	45.0	45.0	45.0	40.0	146.5	146.5	61.6	46.5	140.0	100.0	60.0	58.3
12	57.5	55.0	32.4	36.6	57.5	57.5	48.3	45.0	117.5	127.5	40.0	41.5	146.5	143.0	51.5	65.0
13	55.0	55.0	36.6	38.3	65.0	60.0	52.5	50.0	135.0	132.5	97.5	102.0	146.5	137.5	61.6	65.0
14	61.6	72.5	35.0	43.2	67.5	67.5	52.5	60.0	190.0	200.0	100.0	80.0	193.0	198.0	72.5	92.5
15	60.0	52.5	30.0	32.4	65.0	61.6	55.0	50.0	173.0	163.0	72.5	63.3	163.0	150.0	61.6	70.0
16	58.3	58.3	28.3	36.6	55.0	50.0	46.5	50.0	45.0	137.5	61.6	75.0	122.5	102.0	65.0	70.0
17	45.0	45.0	21.5	30.0	35.0	41.5	32.4	38.3	104.0	115.0	52.5	43.2	100.0	117.5	36.6	50.0
18	45.0	48.3	33.5	33.5	60.0	52.5	43.2	43.2	173.0	143.0	28.3	58.3	163.0	176.5	32.4	52.5
19	58.3	61.6	25.0	35.0	61.6	63.3	61.6	61.6	163.0	200.0	92.5	95.0	137.5	163.0	67.5	77.5
20	58.3	58.3	28.3	25.0	55.0	55.0	48.3	48.3	132.5	117.5	50.0	52.5	127.5	102.0	52.5	55.0
Experimental																
21	52.5	65.0	32.4	30.0	40.0	55.0	35.0	41.5	127.5	125.0	52.5	100.0	110.0	122.5	55.0	70.0
22	43.2	38.3	28.3	28.3	52.5	45.0	38.3	40.0	106.0	104.0	57.5	61.6	127.5	102.0	57.5	46.5
23	55.0	67.5	33.5	38.3	55.0	61.6	57.5	67.5	122.5	160.0	87.5	102.0	127.5	166.5	38.3	61.6
24	61.6	58.3	33.5	40.0	55.0	52.5	55.0	55.0	156.5	173.0	33.5	102.0	153.0	156.5	60.0	65.0
25	61.6	67.5	28.3	36.6	65.0	61.6	46.5	52.5	143.0	146.5	52.5	117.5	143.0	156.5	72.5	77.5
26	48.3	48.3	25.0	35.0	36.6	43.2	30.0	40.0	82.0	95.0	40.0	45.0	127.5	137.5	52.5	67.5
27	60.0	60.0	33.5	35.0	63.0	60.0	46.5	45.0	153.0	156.5	15.0	80.0	195.0	200.0	48.3	67.5
28	57.5	65.0	35.0	52.5	63.3	72.5	57.5	75.0	115.0	87.5	32.4	61.6	170.0	195.0	60.0	61.6
29	45.0	61.6	23.2	32.4	45.0	46.5	32.4	43.2	115.0	153.0	38.3	43.2	80.0	117.5	35.0	43.2
30	48.3	55.0	33.5	36.6	46.5	52.5	38.3	40.0	153.0	200.0	40.0	40.0	110.0	140.0	67.5	63.3
31	48.3	52.5	33.5	28.3	58.3	58.3	38.3	43.2	137.5	153.0	90.0	97.5	120.0	117.5	60.0	61.6
32	45.0	55.0	30.0	41.5	30.0	35.0	30.0	36.6	117.5	110.0	32.4	70.0	106.0	117.5	38.3	50.0
33	52.5	60.0	33.5	38.3	57.5	55.0	46.5	48.3	137.5	130.0	58.3	41.5	137.5	153.0	52.5	58.3
34	60.0	63.3	35.0	35.0	61.6	60.0	57.5	61.6	156.5	176.5	28.3	67.5	153.0	198.0	57.5	61.6
35	65.0	60.0	38.3	33.5	53.2	53.2	53.2	46.5	146.5	180.0	72.5	72.5	135.0	173.0	63.3	53.2
36	48.3	60.0	32.4	30.0	52.5	63.3	41.5	48.3	112.5	90.0	75.0	67.5	160.0	150.0	61.6	61.6
37	61.6	63.3	41.5	36.6	46.5	50.0	43.2	61.6	153.0	163.0	48.3	67.5	130.0	137.5	58.3	80.0
38	57.5	57.5	30.0	33.5	48.3	48.3	41.5	45.0	104.0	132.5	13.7	32.4	106.0	132.5	52.5	61.6
39	57.5	58.3	45.0	48.3	58.3	65.0	48.3	63.3	153.0	166.5	48.3	65.0	122.5	153.0	75.0	75.0
40	67.5	67.5	38.3	40.0	61.6	65.0	50.0	61.6	143.0	146.5	77.5	75.0	137.5	146.5	60.0	65.0
41	52.5	61.6	33.5	32.4	40.0	50.0	30.0	38.3	82.5	90.0	20.0	30.0	110.0	173.0	43.2	60.0
42	55.0	61.6	33.5	36.6	52.5	55.0	50.0	57.5	180.0	200.0	92.5	82.5	166.5	200.0	82.5	92.5
43	52.5	46.5	32.4	36.6	58.3	63.3	45.0	52.5	156.5	163.0	45.0	63.3	173.0	198.0	72.5	72.5
44	48.3	58.3	36.6	48.3	48.3	57.5	38.3	52.5	108.0	104.0	38.3	67.5	92.5	125.0	43.2	75.0
45	50.0	63.0	26.6	36.6	41.5	61.6	33.5	40.0	108.0	143.0	26.6	75.0	112.5	153.0	48.3	63.3
46	63.3	70.0	40.0	48.3	67.5	80.0	63.3	65.0	200.0	186.5	75.0	104.0	153.0	163.0	72.5	72.5
47	57.5	58.3	30.0	40.0	60.0	58.3	52.5	52.5	176.5	195.0	61.6	77.5	132.5	137.5	50.0	52.5
48	63.3	77.5	40.0	45.0	65.0	87.5	58.3	61.6	176.5	200.0	70.0	90.0	153.0	195.0	87.5	95.0
49	58.3	67.5	41.5	45.0	57.5	61.6	48.3	52.5	186.5	186.5	122.5	67.5	146.5	153.0	72.5	65.0
50	40.0	43.2	25.0	25.0	35.0	40.0	23.2	36.6	97.5	115.0	35.0	58.3	77.5	92.5	45.0	46.5
51	43.2	61.6	32.4	35.0	46.5	55.0	36.6	43.2	102.0	163.0	57.5	55.0	166.5	160.0	33.5	63.3
52	50.0	58.3	30.0	35.0	52.5	55.0	36.6	45.0	130.0	163.0	33.5	85.0	153.0	163.0	60.0	58.3

RESULTS OF INFORMAL QUESTIONNAIRE

HPER 1122 - BODY MECHANICS

Please answer each of the following questions honestly and frankly, feeling free to comment on any question that you wish to express an opinion about.

1. What was your initial reaction to the experimental program that was explained to you at the first class session?

2. Were you apprehensive about the appearance of your figure becoming more "masculine" looking?

   [14] yes

   comment:

   [18] no

3. Prior to the experimental session, would you have considered weight training to be an acceptable form of exercise for a female?

   [13] yes

   comment:

   [19] no

4. If a course in weight training for women would have been offered prior to this class, would you have enrolled?

   [8] yes

   [24] no

5. During the first few weeks of the program, did your attitudes about the experiment change or differ from your initial reaction?

   [22] yes

   [10] no

6. During the 10 weeks of training, did you "feel" like you were getting progressively stronger?

[31] yes

[1] no

7. During the 10 weeks of training, your "feelings" about your femininity could best be described as

threatened 1 enhanced 6 no particular feeling 25

8. After 8-9 weeks of participation, how would you have rated your interest and motivation to continue with the program?

*	5	12	7	4	4
(low)	1	2	3	4	5 (high)

9. At the conclusion of the ten weeks of training, did you feel that you had benefited physically from the training?

[31] yes If yes, how?

[1] no If no, why not?

10. Would you recommend weight training to your female friends?

[27] yes

comment:

[5] no

11. Would you use weight training exercises in the future if you had the opportunity to continue to use them?

[26] yes

comment:

[6]

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*Top numbers refer to number of responses.

12. Would you have any fears of developing masculine features if the program were to have been continued for 6 months or a year?

5	yes
18	no
9	not sure

VITA

Ross Thomas Sanders

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFECTS OF A PROGRAM OF PROGRESSIVE RESISTANCE EXERCISE ON STRENGTH, MUSCLE GIRTH, AND BODY COMPOSITION OF COLLEGE WOMEN

Major Field: Higher Education

Minor Field: Health, Physical Education, and Recreation

Biographical:

Personal Data: Born in Miami, Oklahoma, October 15, 1946, the son of Mr. and Mrs. Roy L. Sanders. Married Nancy Jo Kaufman August 20, 1966.

Education: Attended elementary, junior high, and high school in Miami, Oklahoma; graduated from Miami High School in 1964; received the Bachelor of Science degree from Phillips University, May, 1969, with a major in Physical Education; received Master of Education degree in Guidance and Counseling from Phillips University, July, 1970; completed requirements for the Doctor of Education degree in July, 1975.

Professional Experience: Served as an Instructor and Assistant Professor of Health, Physical Education, and Recreation, Director of Intramural Sports, and Assistant Basketball Coach at Phillips University, Enid, Oklahoma, from 1969 to 1971; served as head resident of Willham South Residence Hall, 1971-72 and Head Resident of Iba Residence Hall, 1972-73 at Oklahoma State University; appointed Assistant Athletic Director and Assistant Basketball Coach at Phillips University, 1973-74; served as a graduate teaching assistant in the Department of Health, Physical Education, and Recreation at Oklahoma State University, 1974-75. Member of American Alliance of Health, Physical Education, and Recreation; Oklahoma Association of Health, Physical Education, and Recreation; Central States Chapter of Sports Medicine.