A Comparison of Two Resistance Training Programs on Gains in Strength and Endurance

Pamela S. Canavan
Western Michigan University

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A COMPARISON OF TWO RESISTANCE TRAINING PROGRAMS
ON GAINS IN STRENGTH AND ENDURANCE

by

Pamela S. Canavan

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Health, Physical Education, and Recreation

Western Michigan University
Kalamazoo, Michigan
April 1993
The purpose of the study was to find how two different resistance training programs would contribute to each subject's overall fitness level. Fifty-five subjects were tested to determine their 1RM and the maximum number of repetitions performed at 60% of 1RM. Subjects were then divided into three training groups: control (N=19), strength (N=20), and endurance (N=16). The strength group performed three sets of five repetitions each and two sets of three repetitions. The endurance group performed three sets of 15 repetitions. At the completion of the six week training programs, the subjects were retested. A significant difference was found between training programs for changes in strength and in endurance (p < .05). There was no significant difference in the amount of strength gained based on experience level or initial strength level. Also, there was no significant difference in the initial endurance level regarding initial strength level.
ACKNOWLEDGEMENTS

Without Dr. Mary Dawson, I would not have been able to complete this thesis. Her advice and support have been invaluable. I would also like to thank the other members of my committee for their helpfulness and suggestions, Dr. Roger Zabik and Dr. Debra Berkey.

I'd also like to thank my parents who have been supportive of all my academic endeavors. A special thanks goes to my husband, Donald Canavan, for his computer expertise, and more importantly, for his support throughout the duration of this project.

Pamela S. Canavan
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A comparison of two resistance training programs on gains in strength and endurance

Canavan, Pamela Sue, M.A.

Western Michigan University, 1993
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CHAPTER I

INTRODUCTION

Resistance training programs have traditionally been designed to increase either muscular strength or muscular endurance. Very little consideration has been given to whether one resistance training program may be able to increase both. In fact, many researchers have suggested that such a program would theoretically be impossible to design because strength and endurance are mutually exclusive. This has been referred to as the principle of specificity. This principle, presented by DeLorme in 1945, stated that training for strength (high resistance, low repetition designated HR, LR) would lead to improvements only in strength, without a corresponding increase in endurance. An endurance program of low resistance, high repetition (designated LR, HR) would lead to an increase in endurance without an increase in strength. This led DeLorme to suggest that muscles made specific adaptations to a particular mode of training.

In the years since DeLorme's (1945) study was completed, some researchers have studied the principle of specificity when applied to all individuals. Some researchers found that both strength and endurance were increased after training while others supported the principle of specificity.
Statement of the Problem

The problem of this study was to compare the effects of two weight training programs. This study compared a weight training program designed to increase strength with one designed to increase endurance. Differences between the programs were based on training factors; these training factors were number of repetitions performed and percentage of one repetition maximum. Specifically, the investigation compared the differences in strength and endurance gained due to training program, gender, and the subject's initial level of weight training experience.

Purpose of the Study

The purpose of this study was to find how two different weight training programs would contribute to the subjects' overall fitness levels. If one program increased both strength and endurance, this program could then be used in a variety of situations to increase general fitness. It is possible that a program which would increase both strength and endurance might exist. However, such a program might be different for individuals who have different goals or experience levels. Variations may also occur for each gender.
Need for the Study

Ribley (1988) stated the importance of resistance training as a part of an overall fitness program. Resistance training is often overlooked in fitness programs due to the emphasis on improving cardiovascular fitness. When prescribed, resistance training programs have traditionally been designed to increase either strength or endurance, not both. The resistance training program prescribed has most often been based on the goals of the individual and his/her gender. For example, most females have been placed on a program to increase muscle tone, while most males have been placed on a program designed to increase strength. Little thought is given to the possibility that one program may lead to an increase in both attributes, at least for some individuals. Most exercise physiologists do not consider this to be possible because it contradicts the principle of specificity. It is also possible that all individuals will not respond to the same weight training program in the same way. If both strength and endurance could be improved by one program, or if it was found that certain groups responded to resistance training programs in different ways, it may have an effect on exercise prescription and the design of resistance training programs.
Delimitations

This study was delimited in the following ways:

1. The subjects were students, 18 to 25 years old, and enrolled in General Physical Education Classes at Western Michigan University, Kalamazoo.

2. The subjects participated in an assigned weight training program three times per week for six weeks.

3. The training programs were designed to exercise the shoulder girdle and the upper extremities.

Limitations

The limitations of this study were as follows:

1. During the testing and training periods, there was no way to determine if the subjects were exerting maximal efforts.

2. Attendance at the training sessions was not 100%.

Assumptions

The assumptions of this study were as follows:

1. The subjects participating were representative of the 18 to 25 year old student population.

2. The subjects gave maximum efforts during testing and training periods.

3. Any improvement in the subjects' pretests and posttests
were due to participation in their assigned training program.

Research Hypotheses

The hypotheses tested in this study were as follows:

1. Subjects participating in the high resistance, low repetition training program showed greater gains in strength than in endurance.

2. Subjects participating in the low resistance, high repetition training program showed greater gains in endurance than in strength.

3. Subjects participating in the high resistance, low repetition training program gained more strength than the subjects in the low resistance, high repetition training program.

4. Subjects participating in the low resistance, high repetition training program gained more endurance than the subjects in the high resistance, low repetition training program.

5. Gains in relative strength were the same for males and females.

6. Gains in relative endurance were the same for males and females.

7. Subjects with more weight training experience gained less strength than those subjects with less weight training experience.

8. Subjects with a high level of initial strength had a lower level endurance than those with a low level of initial
9. Subjects with a high level of initial strength gained less strength than those with a low level of initial strength.

Definitions

The following terms were used in this study:

1. Endurance - the ability to exert submaximal forces for a period of time.

2. High resistance, low repetition training program - a weight lifting workout where the individual lifts a high percentage (80 to 90%) of his/her one repetition maximum a low number of times (one to five).

3. Low resistance, high repetition training program - a weight lifting workout where the individual lifts a low percentage (50 to 60%) of his/her one repetition maximum a high number of times (15 to 20).

4. One repetition maximum - the maximum amount of weight an individual can lift one time, using correct form.

5. Repetition - one complete cycle of a lift (both the up and the down movements).

6. Strength - the ability to exert a maximal force in a single effort (Lamb, 1984).
CHAPTER II

REVIEW OF LITERATURE

The Specificity of Resistance Training Programs

DeLorme (1945) has been credited with proposing the concept of muscular specificity. He studied the effects of various resistance training programs on the restoration of muscle power. After he completed his studies, he concluded that muscles made specific adaptations to a particular resistance training program. If the individual had trained with a low resistance, DeLorme found that he/she gained endurance. Power was gained only after heavy resistance training. Each of these training programs produced entirely different results. DeLorme felt that when muscles were recruited to perform a function for which they had not been trained, the muscles would not perform as well as if they were called upon to perform a function for which they had been trained. DeLorme concluded that there was a direct relationship between the training protocol used and the type of function the muscles could perform. DeLorme stated that training for muscular strength led to decrements in muscular endurance, while training for muscular endurance led to decrements in muscular strength.

In 1948, DeLorme and Watkins attempted to standardize
resistance training terminology so researchers could better communicate with each other. Resistance training programs designed to increase strength consisted of high resistance and low repetitions, and were designated HR, LR. Programs designed to increase endurance were referred to as low resistance and high repetitions, which were designated LR, HR.

Traditionally, resistance training programs have been prescribed for both athletes and the general population following DeLorme's (1945) principle of specificity. If the goal was to increase strength, repetitions were kept low (HR, LR). If the goal was increased muscle tone and endurance, repetitions were increased (LR, HR). Although some studies have been completed that indicated that this method for prescribing resistance training programs may not produce the desired results for all individuals, most exercise physiologists have continued to follow this method for exercise prescription. In fact, despite the amount of research that has been done on the effect of resistance training programs, there does not seem to be any consensus among researchers regarding the effects of these programs (Alway, 1992). The purpose of this research was to explore how two different types of resistance training programs affected college-age males and females. These two programs may have a different effect on people of other ages.

One problem in evaluating resistance training research has been the discrepancies in testing and training. Although
DeLorme and Watkins (1948) systemized resistance training terminology, there is still a great deal of variability in training programs and in testing methods. In fact, as Hakkinen (1985) indicated, it has been very difficult to interpret the results of resistance training studies because there has been a general lack of uniformity in the experimental design used by the researchers. Thus, it has often been difficult to compare different resistance training studies and to draw conclusions about them.

A study by Anderson and Kearney (1982) supported the principle of specificity. Subjects were college-age males randomly assigned to one of three training programs utilizing the bench press. The subjects in the LR, HR training program performed six to eight repetitions, while those in the LR, HR training program performed 100 to 150 repetitions. A third group performed 30 to 40 repetitions (medium resistance and medium repetitions, designated MR, MR). These training programs followed a progressive resistance format. When the subjects could perform the maximum number of repetitions required in their group, five pounds were added to what the subjects lifted the next time.

Subjects were pretested and posttested to find their one repetition maximum (1RM), their absolute endurance (the number of times they could lift 27.23 kilograms), and their relative endurance (the number of times the subject could
lift 40% of 1RM). The resistance used for the posttest for relative endurance was the same resistance which was used in the pretest (based on the subject's pretest 1RM).

When Anderson and Kearney (1982) performed an ANOVA, they found no significant differences between the strength and endurance gained for the three groups. Through the use of the Tukey procedure, however, they did find a significant difference between the three groups. The subjects in the HR, LR group gained significantly more strength (20%) than those in either the MR, MR group (eight percent) and the LR, HR group (five percent). Relative endurance was also significantly different for the three groups. Relative endurance decreased for the HR, LR group by seven percent while those in the MR, MR group gained 22% and those in the LR, HR group gained 28%. There was no significant difference in absolute endurance between the three groups. The conclusion was that muscles made both general and specific adaptations dependent on the intensity and duration of the training program used.

The results of a study by Gillespie and Gabbard (1984) conflicted with the results of Anderson and Kearney's (1982) study. Subjects were males involved in one of three resistance training programs utilizing the bench press. The first group performed three sets of six to eight repetitions (HR, LR), the second group performed three sets of 15 to 20 repetitions (LR, HR), and the third group performed one set of six to
eight repetitions, followed by a set of as many repetitions as possible (combination of HR, LR and LR, HR). When subjects could perform more repetitions in the last set than required for the training program, five pounds were added to the individual's training resistance. Strength was pretested and posttested by measuring the subject's 1RM. The subject's weight was taken and divided into his/her 1RM. Endurance was measured as the number of repetitions that could be performed using 60% of the subject's 1RM. The posttest resistance for the endurance test was the same as that used in the pretest.

The statistical results showed that there was no significant difference in the strength and absolute endurance gained by the three training groups. The strength ratio increased by .24 for the HR, LR group, .20 for the LR, HR group, and by .20 for the combination group. The number of repetitions in the endurance test increased by 5.65 for the HR, LR group, by 6.38 for the LR, HR group, and by 8.05 for the combination group. Due to these results, Gillespie and Gabbard (1984) indicated that one training program could be used to increase strength and endurance. The most effective method for the enhancement of both strength and endurance seemed to be a combination of HR, LR and LR, HR training.

Meadors, Crews, and Adeyanju (1983) had female subjects perform three different sets of up to 13 repetitions at 50%, 60%, and 83% of 1RM. The other group followed the DeLorme
(1945) program in which they performed one set at 50% of their ten repetition maximum (i.e. the maximum amount of weight that the subject could lift ten, but not an eleventh time). These subjects then performed a second set at 75% of the ten repetition maximum and a third set at 100% of the ten repetition maximum. All subjects performed a variety of resistance training exercises. No significant differences were found in the amount of strength gained after completion of the training programs. There was also no significant difference from the pretest to the posttest in the number of repetitions performed at 50% of the pretest 1RM.

Stull and Clarke (1970) tested 20 male college students for elbow flexion strength and endurance. Endurance was tested by having the subject perform a five minute bout of rhythmic elbow flexor exercise. Strength was measured by averaging three contractions which occurred at 30 second intervals. Subjects were also tested to find the maximum amount of weight they could lift ten times. After the testing, the subjects participated in a training program of bicep curls at 50, 75, and 100% of the 10RM. The principle of progressive resistance was employed, so the subjects gradually increased the weight of their ten repetitions maximum. Stull and Clarke found that strength and absolute endurance were increased as a result of this training program. Relative endurance, however, was not increased.
Another study by Clarke and Stull (1970) measured strength and endurance in the same manner as in the previous study. In this study, however, the training program was designed to increase endurance rather than strength. Subjects performed one all-out bout of elbow flexion on an upper body ergometer at 40 repetitions per minute against a resistance of 11.03 pounds. The results of this training program increased not only absolute endurance, but also increased the strength as measured by averaging three consecutive elbow flexions on the arm ergometer. Again, relative endurance was not increased.

Subjects in a study by DeLateur, Lehmann, and Fordyce (1968) were males 18 to 35 years of age. These subjects trained their quadriceps muscle with a leg extension exercise. The leg was extended at 60 repetitions per minute against either 25 pounds or against 55 pounds. The subjects worked until fatigue. Subjects who extended their leg against the 55 pounds worked for up to five minutes, while those who worked against 25 pounds worked for as long as 80 minutes. The results showed that those who trained for strength (against 55 pounds) gained as much endurance as those who trained for endurance (against 25 pounds). Those who trained for endurance gained as much strength as those who trained for strength. DeLateur et al. felt that the results of this study indicated that the number of repetitions was not the important factor in improving strength and endurance. Rather, as long as the subjects worked until
fatigue, they would increase both strength and endurance.

Hunter (1985) used male and female subjects in his study. They trained three times per week for seven weeks using 50% of 1RM. Upon completion of the study, Hunter found that both the strength and endurance had increased.

Hoeger, Hopkins, Barette, and Hale (1990) found that relative endurance was not significantly different for males of high and low strength. When lifting 40, 60, and 80% of 1RM. However, there was a significant difference in the relative endurance of females at 60 and 80% of 1RM (no data was available for 40%).

Kraemer and Fleck (1988) found that performing sets of six repetitions elicited strength gains. They felt, however, that sets of two to ten repetitions would elicit strength gains for most individuals. If resistances were decreased, and the number of repetitions the person completed increased, the person would not gain as much strength. Kraemer and Fleck felt that performing 20 to 25 repetitions would enhance motor performance, while performing repetitions over 20 would increase endurance.

Initially, Hoeger, Barrette, Hale, and Hopkins (1987) felt that for strength gains to occur, muscles had to be overloaded with a resistance high enough to cause physiological adaptations in the muscles. Hoeger et al. (1990) stated that the amount of overload may need to be nearer to 85% for strength gains.
to occur especially when considering large muscles. The results of their research led them to believe that a person must work at 60% of his/her one repetition maximum or greater to stimulate strength development. If subjects worked at a percentage of the 1RM that allowed them to complete more than ten repetitions, the subjects would increase endurance.

One factor that may have affected the amount of strength gained was the experience level of the subjects. Researchers have noted that great initial improvements in strength occur when an individual begins a resistance training program (Fleck & Kraemer, 1988; Hakkinen, 1985; Yessis, 1986). For example, the subjects in the study by Hakkinen (1985) increased their strength by up to ten percent after only two weeks of resistance training. Hakkinen felt that since most subjects did not exhibit muscular hypertrophy after a short training period, the only way to account for the increase in strength was the learning effect. Untrained individuals were able to increase strength because of adaptations in neural activities (Hakkinen, 1985; Yessis, 1986). Fleck and Kraemer found that initial strength gains in the first two to six weeks of training due to neural factors. It was unlikely that these rapid increases in strength were due to muscular adaptations. Gonyea and Sale (1982) stated that increased strength could be achieved by learning how to recruit more motor units in a muscle and also to better synchronize individual muscle activity. Thus,
subjects with little resistance training experience gained a great deal of strength initially because of the use of new neural pathways. However, as these neural pathways were perfected as through practice, the only way to continue to gain strength was through long-term training which led to muscular hypertrophy (Gonyea & Sale, 1982). Moritani and DeVries (1979) indicated that hypertrophy would begin to occur after four to six weeks of training. Until that time, changes in strength were due to neural changes rather than changes in muscle.

Another factor that may have affected the amount of strength gained by subjects after training was their initial strength level. Researchers have suggested that subjects who were initially stronger would gain more strength than those who were initially weaker (Hakkinen, 1985; Jette, Sidney, Regimbal, Barsalou, & Montelpare, 1987; Michael & Parrish, 1978; O'Shea, 1966; Yessis, 1986). Subjects with a greater initial strength were more limited in the amount of strength gained after training compared to those subjects with a lower pretraining strength (Hakkinen, 1985). Michael and Parrish (1978) suggested that if physiological and mechanical limits were similar for all individuals regardless of initial strength, a stronger individual would reach these limits more quickly than a weaker individual. Weaker subjects would be able to gain more strength before they reached their limits.
The Relationship Between Strength and Endurance

Research has indicated that endurance may be affected by initial strength level. Subjects with initially higher strength have a lower endurance level (Berger, 1964; McGlynn, 1969; Noble & McCraw, 1973). McGlynn (1969) found that subjects with stronger muscles fatigued faster when performing muscular endurance exercise than those with weaker muscles. Berger found that subjects with greater strength had less relative endurance when lifting 50% of 1RM.

Hoeger et al. (1990) indicated that increased muscle mass interfered with the muscle's ability to supply oxygen to the cell, thereby decreasing the removal of waste from the cells.

Martens and Sharkey (1966) thought there was a direct relationship between strength and endurance. The amount of muscular endurance depended on the individual having adequate muscle strength to perform muscular endurance activities. This relationship was unpredictable, however, because a variety of factors affected the relationship. The factors which led to the most variability seemed to be the methods used in endurance testing and training because no guidelines have been set for these procedures. Noble and McCraw (1973) indicated that although strength and endurance were related, an increase in strength would not necessarily lead to a proportional increase.
in endurance.

Gender and Resistance Training

A secondary purpose of this study was to determine whether males and females responded the same way to different types of resistance training. Although the response of males to resistance training has been well-documented, there have been few studies which used females as subjects (Brown & Wilmore, 1974; Oyster, 1979).

Most of the resistance training studies that have included female subjects have been completed only to find if any differences exist in the strength levels of males and females, not the differences (if any) in the responses to resistance training. A review of literature found that no matter how strength was expressed, females were considerably weaker than males in upper body strength. Laubach (1976) indicated that females averaged only 55.8% of the upper body strength of males. Researchers have attributed this strength differential to dissimilar use of the upper body between the genders (Heyward, Johannes-Ellis & Romer, 1986; Jette et al., 1987; Wilmore, 1974). These researchers felt it was necessary to determine if, given the opportunity, females could make similar gains in strength to those of males after resistance training or if physiological differences between the genders would not allow females to gain as much upper body strength.
As reported by O'Shea and Wegner (1981) and Oyster (1979), there were a number of questions about the capability of females to tolerate heavy resistance training. Thus, O'Shea and Wegner set out to find out how females would respond to heavy resistance training. Thirteen males and 13 females were put on a power lifting program which duplicated a program followed by competitive male weight lifters. The results showed that subjects of both genders dramatically improved their strength after a seven week training program. The conclusion was that females had the same capability as males to tolerate and adapt to the physical stress of heavy resistance training.

Capen, Bright, and Line (1961) indicated that there was no reason to suspect that females would not respond the same way to strength training as males. In 1974, Brown and Wilmore agreed and stated that females were capable of achieving greater gains in strength than had previously been reported if females were given an opportunity to train with heavy weights. Females were used in a study by Brown and Wilmore to determine how females responded to resistance training. The females participated in a six month all over body lifting program. The results of the study indicated that females were capable of gaining considerable strength after resistance training.

Wilmore (1974) found that males and females both increased bench press strength after training (by 16.5% and 28.6%, respectively). Wilmore concluded that the quality of muscle found in the
upper body of both genders was identical. There was no differences in the contractile properties and the ability of the muscles to exert force. Therefore, Wilmore concluded that females have the same potential for strength development as males of comparable size. In fact, Clarke (1986) found that females increased their relative strength even more than males.

Since 1974, studies by Stamford (1987), O'Shea and Wegner (1981), and Brown and Harrison (1986) have supported the conclusion that females respond in the same way to resistance training as males. A study by Miller, Hunter, and Dement (1985) also led to this conclusion. The purpose of this study was to monitor the strength changes between males and females after an eight week training program. The results showed that strength changes were statistically insignificant between the genders. The only difference found between genders after training were differences in body composition. Males increased lean body mass more than females. Brown and Wilmore (1974) attributed the differential gain in lean muscle mass to the higher testosterone levels of males. In addition, the higher percentage of body fat in females adversely affected their ability to attain muscle hypertrophy (Stamford, 1987), but it would not affect their ability to gain strength. O'Shea and Wegner (1981), and McArdle, Katch, and Katch (1981) supported this statement. The conclusion was that females had the capability to increase strength, but females generally did not have the same capability
as males to develop large muscle masses.

Although Michael and Parrish (1978) found that both genders achieved rapid gains in strength, males and females responded differently to resistance training. Differences in the amount of upper body strength between the genders were related to differential composition of the muscles. Males had a larger proportion of white muscle fibers, while females had a larger proportion of red fibers. Michael and Parrish hypothesized that resistance training caused a greater increase in the size and the strength of the white muscle fibers. Training of red muscle fibers would cause an increased enzymatic functioning, leading to increased endurance. Thus females, due to greater proportion of red muscle fibers, increased endurance more than strength through resistance training. Males, however, with a higher proportion of white muscle fibers, would increase the size of these fibers, leading to an increased strength.

The conclusion reached by Michael and Parrish was that resistance training would increase strength and endurance in both genders, but the changes taking place would be different for each sex.

The majority of research, however, indicated that both genders responded to resistance training in a similar manner. Brown and Wilmore (1974) felt that there was enough evidence to indicate that females responded in the same way to resistance training as males. Thus, similar training and testing methods should be used for males and females. However, due to the
many misconceptions regarding females and resistance training, many programs have been designed specifically for females. Most of these programs have the females lifting a low resistance a high number of times. Many females and trainers felt this was necessary to prevent them from becoming masculinized. The prevailing thought was that if females lifted heavy weights like males did, they would have large muscles (O'Shea & Wegner, 1981; Oyster, 1979; Stamford, 1987). However, since females did not have enough testosterone to increase their muscle size to a great extent (Stamford, 1987), they would not become masculinized. However, despite this evidence, many females have been reluctant to lift weights.

Another misconception has dealt with the capability of females to tolerate heavy resistance training (O'Shea & Wegner, 1981; Oyster, 1979). Many people felt that females were too frail to be able to lift heavy weights. O'Shea and Wegner (1981) and Brown and Wilmore (1974) found that females were capable of tolerating heavy resistance training. Many of the differences found between the genders after training were due to psychological, not physiological, factors. McArdle et al. (1981) agreed with this conclusion. Many females have had a fear of weight lifting and had been adversely affected by the perceptions of society toward females lifting weights. McArdle et al. felt that this had adversely affected the ability of many female athletes to compete on the international level,
because females in America were not as likely to train with weights as females in other countries. American females had not been exposed to the same quality of weight lifting programs as the males had been over the years.

The research listed above has shown females were capable of lifting heavy weights, and they can expect to be as successful as males who lift weights. They can also attain the same benefits as males through lifting weights, including improved athletic performance, resistance to injuries, and more defined physiques.
CHAPTER III

EXPERIMENTAL PROCEDURES

The purpose of this investigation was to compare the effects of two different resistance training programs on gains in strength and endurance for males and females. The procedures used in the investigation were grouped as follows: (a) subjects, (b) exercise, (c) treatment procedures, (d) data collection, and (e) statistical analysis.

Subjects

Subjects were healthy volunteers from General Physical Education Classes at Western Michigan University, Kalamazoo. The average age of the male subjects (N = 25) was 20.68 years, while the average age of the female subjects (N = 30) was 20.53 years. Subjects agreed to limit their weight training (for their chest muscles) to the training sessions only. An effort was made to have subjects make up any missed sessions, however, subjects were never allowed to lift three days in a row. Subjects were informed that they could discontinue participating in the study for any reason. All of the subjects read and signed an informed consent form (Appendix A). Western Michigan University's Human Subjects Institutional Review Board for Research Involving Human Subjects approved the project.
See Appendix B for letter of approval.

Exercise

The bench press was the exercise chosen for all testing and training sessions. The bench press was chosen because of its ease of administration and because of the familiarity of the exercise to the subjects (Berger, 1962). The bench press has been shown to be a reliable (.93), an objective (.97), and valid (content validity) measure of muscular function of the arm and shoulder in extension (Thomas & Nelson, 1985). Free weights were used to give a higher level of sensitivity (accurate to five pounds) than could be achieved by most bench press machines.

Treatment Procedures

This study was conducted over a six week period and was comprised of 19 training sessions and four testing sessions. The first session was used for strength pretesting. The second session was used for endurance pretesting and for signing informed consent forms. The next 19 sessions were used for the subjects' training programs. Sessions were held on Monday, Wednesday, and Friday from either 9:00 A.M. to 11:00 A.M. or from 12:00 P.M. to 1:00 P.M.

The endurance group (following the low resistance, high repetition program) consisted of eight male subjects and eight
female subjects. The training program consisted of 15 repetitions at 60% of each subject's one repetition maximum. There was approximately a two minute rest between sets.

The strength group (following the high resistance, low repetition program) consisted of nine males and 11 females. This group completed three sets of five repetitions at 80% of the subject's one repetition maximum. The next two sets of three repetitions each were performed at 90% of the subject's one repetition maximum. The rest period between sets was also approximately two minutes.

Both training programs incorporated the progressive resistance program suggested by DeLorme and Watkins (1948). When a subject could complete all repetitions in the training program (using correct form and through the complete range of motion), he or she would try a new maximum which was five pounds heavier than his or her previous one repetition maximum. The subject's weight for each of the sets would then be increased to coincide with the new repetition maximum. All subjects attempted a new repetition maximum three weeks into the program. The progressive resistance program was used throughout the 19 training sessions.

Data Collection

Pretesting and posttesting were performed on each subject. Both testing sessions lasted two days; the first day was used
for strength testing and the second day (two days later) was used for endurance testing. Strength was tested by finding the one repetition maximum for each subject. Each subject chose a weight which was close to the maximum amount he or she could lift. If the subject had little weight lifting experience and did not know his or her maximum, the investigator chose the initial weight for the subject to try to lift one time. After each successful lift, either five or ten pounds were added at the discretion of the investigator. This process continued until the subject could no longer lift the weight using correct form (which had been demonstrated and explained before testing began). The repetition maximum scores were recorded in five pound intervals.

The endurance pretesting was completed two days later. The weight used for this test was 60% of the subject's one repetition maximum. Each subject performed as many repetitions as possible with this weight. The test was over when the subject could no longer lift the weight through the complete range of motion. The endurance scores were recorded as the number of repetitions completed.

Each subject's body weight was also taken on this day. The weight was recorded to the nearest pound. The subject's one repetition maximum was divided by his or her weight to obtain strength per pound of body weight. This technique for assessment helped control for the effects of body weight.
on strength. This relative strength measure was used in the data analysis.

The posttesting followed the same procedures as the pretesting. Strength posttesting was completed on the next to the last day of the study. The endurance posttesting was with 60% of the subject's new one repetition maximum. The endurance posttesting and the final weighing of the subject were completed on the last day.

Statistical Analysis

The independent variables were the training program in which the subject participated, the pretest and posttest, the subject's gender, and the two grouping variables, experience level and initial strength level. This study showed the effects of these independent variables on the dependent variables; relative strength and endurance gained from participation in a training program. Learning may have been an intervening variable due to the pretest and training programs. However, since the bench press was a simple exercise familiar to the subjects, it was unlikely that the learning effect played a role in any improvement of scores from the pretest to the posttest.

The data was analyzed using a Split-Plot Factorial Design. The BMDP2V (Dixon, 1983) and the SPSS (SPSS Incorporated, 1988) computer programs were used to calculate the statistics.
CHAPTER IV

RESULTS AND DISCUSSION

This chapter includes the results and discussion of the difference found between the amount of strength and endurance gained by 55 subjects (30 females and 25 males) participating in two resistance training programs. The changes in strength and endurance were analyzed with regard to training program, gender, subject's experience level, and the subject's initial strength level.

The purpose of this study was to find how two different weight training programs would contribute the subjects' overall fitness levels. If one program increased both strength and endurance, this program could then be used in a variety of situations to increase general fitness.

The data were analyzed at Western Michigan University using the BMDP-2V (Dixon, 1983) and the SPSS (SPSS Incorporated, 1988) computer programs. Three different Analyses of Variance (ANOVA), Split Plot Factorial Designs, were used to determine the effects of the independent variables on the dependent variables, relative strength and endurance.

The dependent variables were the amount of relative strength and endurance gained by the subjects. The independent variables were training programs (with three levels: control, strength,
endurance), gender, experience level (high, low) and initial
strength level (high, low). This chapter is presented in
two sections: (1) results and (2) discussion.

Results

Strength Changes

Descriptive data for strength, the dependent variable,
were divided into cells by the independent variables, training
program and gender. Cell means, standard deviations, and
marginal means were calculated, and have been included in
Appendix C. An ANOVA (Table 1) indicated the following:

1. There was a significant difference in the amount
of strength gained $F = 9.52$, between training programs ($F(2,49) = 3.19$, $p < .05$). The means were .6357, .8616, and .8321
for the control, endurance, and strength groups, respectively.

2. There was a significant difference in the amount
of strength gained, $F = 104.02$, between genders ($F(2,49) = 4.04$, $p < .05$). The means were .5709 for females and 1.0151
for males.

3. There was no significant interaction, $F = 2.00$, between
training program and gender regarding the amount of strength
gained ($F(2,49) = 3.19$, $p < .05$). The means can be found
in Appendix C.

4. There was a significant difference, $F = 157.15$, between
pretest and posttest scores strength scores ($F(1,49) = 4.04$,
5. There was a significant difference, $F = 45.06$, for the first order interaction effect, pretest/posttest strength scores and training programs ($F(2, 49) = 3.19, p < .05$).

6. There was no significant difference, $F = 3.47$, for the first order interaction effect, pretest/posttest strength scores and gender ($F(1, 49) = 4.04, p < .05$).

7. There was a significant second order interaction effect, $F = 3.20$, for pretest/posttest strength scores, training programs, and gender ($F(2, 49) = 3.19, p < .05$).

Endurance Changes

Descriptive data for endurance, the dependent variable, were divided into cells by the independent variables, training programs and gender. Cell means, standard deviations, and marginal means were calculated, and have been included in Appendix C. An ANOVA (Table 2) indicated the following:

1. There was no significant difference in the amount of endurance gained, $F = 1.01$, between training programs ($F(2, 49) = 3.19, p < .05$). The means were 24.58, 23.00, and 26.48 for the control, endurance, and strength groups, respectively.

2. There was a significant difference in the amount of endurance gained, $F = 28.67$, between genders ($F(1, 49) = 4.04, p < .05$). The means were 29.50 for females and 20.16
Table 1

ANOVA Summary Table for Strength Changes

<table>
<thead>
<tr>
<th>Source</th>
<th>S.S</th>
<th>df</th>
<th>M.S.</th>
<th>F</th>
</tr>
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<td>Between Subjects</td>
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<td>54</td>
<td></td>
<td></td>
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<tr>
<td>A (Program)</td>
<td>.95</td>
<td>2</td>
<td>.47</td>
<td>9.52*</td>
</tr>
<tr>
<td>B (Gender)</td>
<td>5.19</td>
<td>1</td>
<td>5.19</td>
<td>104.02**</td>
</tr>
<tr>
<td>A x B</td>
<td>.20</td>
<td>2</td>
<td>.10</td>
<td>2.00</td>
</tr>
<tr>
<td>Error</td>
<td>2.44</td>
<td>49</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre/Post</td>
<td>.23</td>
<td>1</td>
<td>.23</td>
<td>157.15*</td>
</tr>
<tr>
<td>Pre/Post x A</td>
<td>.13</td>
<td>2</td>
<td>.07</td>
<td>45.06**</td>
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<tr>
<td>Pre/Post x B</td>
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<td>1</td>
<td>.005</td>
<td>3.47</td>
</tr>
<tr>
<td>Pre/Post x A x B</td>
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<td>2</td>
<td>.005</td>
<td>3.20*</td>
</tr>
<tr>
<td>Error</td>
<td>.07</td>
<td>49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*F(1,49) = 4.04, p < .05

**F(2,49) = 3.19, p < .05

for males.

3. There was no significant interaction, F = 2.84, between training programs and gender regarding changes in endurance (F(2, 49) = 3.19, p < .05). The means can be found in Appendix C.

4. There was a significant difference, F = 22.02, between pretest and posttest scores regarding changes in endurance
5. There was a significant difference, \( F = 23.44 \), for the first order interaction effect, pretest/posttest endurance scores and training programs \( (F(2, 49) = 3.19, \ p < .05) \).

6. There was a significant difference, \( F = 12.05 \), for the first order interaction effect, pretest/posttest endurance scores and gender \( (F(1, 49) = 4.04, \ p < .05) \).

7. There was a significant second order interaction effect, \( F = 7.38 \), for pretest/posttest endurance scores, training programs, and gender \( (F(2, 49) = 3.19, \ p < .05) \).

**Experience Level**

Subjects were divided into either a high or low experience group depending on experience level. Along with experience level, the other two independent variables were training program and gender. The dependent variable was the change in strength over the six week training program. The ANOVA (Table 3) indicated the following:

1. There was a significant difference in strength, \( F = 5.044 \), between training programs \( (F(1, 28) = 4.20, \ p < .05) \). The means were .8616 for the endurance group and .8321 for the strength group.

2. There was no significant difference in strength, \( F = 2.802 \), between experience levels \( (F(1, 28) = 4.20, \ p < .05) \). The means were .9656 for those with a high level of
Table 2
ANOVA Summary Table for Endurance Changes

<table>
<thead>
<tr>
<th>Source</th>
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<td>Between Subjects</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (Program)</td>
<td>150.66</td>
<td>2</td>
<td>75.33</td>
<td>1.01</td>
</tr>
<tr>
<td>B (Gender)</td>
<td>2128.29</td>
<td>1</td>
<td>2128.29</td>
<td>28.67*</td>
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<tr>
<td>A x B</td>
<td>421.44</td>
<td>2</td>
<td>210.72</td>
<td>2.84</td>
</tr>
<tr>
<td>Error</td>
<td>3637.77</td>
<td>49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre/Post</td>
<td>324.20</td>
<td>1</td>
<td>324.20</td>
<td>22.02*</td>
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<tr>
<td>Pre/Post x A</td>
<td>690.11</td>
<td>2</td>
<td>345.06</td>
<td>23.44**</td>
</tr>
<tr>
<td>Pre/Post x B</td>
<td>177.39</td>
<td>1</td>
<td>177.39</td>
<td>12.05*</td>
</tr>
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<td>Pre/Post x A x B</td>
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<td>2</td>
<td>108.64</td>
<td>7.38**</td>
</tr>
<tr>
<td>Error</td>
<td>721.31</td>
<td>49</td>
<td>14.72</td>
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</tr>
</tbody>
</table>

*F (1, 49) = 4.04, p < .05

**F (2, 49) = 3.19, p < .05

experience and .7259 for those with a low experience level.

3. There was a significant difference in strength, $F = 6.220$, between genders ($F(1, 28) = 4.20, p < .05$). The means were .5709 for females and 1.0151 for males.

4. There was no significant interaction, $F = 1.862$, between training program and experience level regarding strength change ($F(1, 28) = 4.20, p < .05$). The means are included.
5. There was a significant interaction, $F = 5.967$, between training program and gender regarding strength change ($F(1, 28) = 4.20, p < .05$). The means are included in Appendix C.

6. There was no significant interaction, $F = .054$, between experience level and gender regarding strength change ($F(1, 28) = 4.20, p < .05$). The means are included in Appendix C.

7. There was no significant interaction, $F = .289$, between training program, experience level, and gender regarding strength change ($F(1, 28) = 4.20, p < .05$). The means are included in Appendix C.

### Initial Strength Level

Subjects were divided into either a high or low strength group depending on initial strength level. With the initial strength level, the other two independent variables were training program and gender. The dependent variable was the change in strength over the six week training program. The ANOVA (Table 4) indicated the following:

1. There was no significant difference in strength, $F = .166$, between training programs ($F(1, 28) = 4.20, p < .05$). The means were .8616 for the endurance group and .8321 for the strength group.
Table 3
ANOVA Summary Table for Experience Level

<table>
<thead>
<tr>
<th>Source</th>
<th>S.S.</th>
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<td>Main Effects</td>
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<td>3</td>
<td>.011</td>
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</tr>
<tr>
<td>A (Program)</td>
<td>.014</td>
<td>1</td>
<td>.014</td>
<td>5.044*</td>
</tr>
<tr>
<td>B (Experience)</td>
<td>.008</td>
<td>1</td>
<td>.008</td>
<td>2.802</td>
</tr>
<tr>
<td>C (Gender)</td>
<td>.018</td>
<td>1</td>
<td>.018</td>
<td>6.220*</td>
</tr>
<tr>
<td>Two Way Interactions</td>
<td>.028</td>
<td>3</td>
<td>.009</td>
<td></td>
</tr>
<tr>
<td>A x B</td>
<td>.005</td>
<td>1</td>
<td>.005</td>
<td>1.862</td>
</tr>
<tr>
<td>A x C</td>
<td>.017</td>
<td>1</td>
<td>.017</td>
<td>5.967*</td>
</tr>
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<td>B x C</td>
<td>.000</td>
<td>1</td>
<td>.000</td>
<td>.054</td>
</tr>
<tr>
<td>Three Way Interaction</td>
<td>.001</td>
<td>1</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>A x B x C</td>
<td>.001</td>
<td>1</td>
<td>.001</td>
<td>.289</td>
</tr>
<tr>
<td>Residual</td>
<td>.080</td>
<td>28</td>
<td>.003</td>
<td></td>
</tr>
</tbody>
</table>

*F = 4.20, p < .05

2. There was no significant difference in strength, F = 1.916, between subjects with low initial strength and those with high initial strength (F(1, 28) = 4.20, p < .05). The means were .9630 for those with a high initial strength and .7135 for those with a low initial strength.

3. There was no significant difference in strength, F = 2.464, between genders (F(1, 28) = 4.20, p < .05). The means were .5709 for females and 1.0151 for males.
Table 4
ANOVA Summary Table for Initial Strength Level

<table>
<thead>
<tr>
<th>Source</th>
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<th>F</th>
</tr>
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<tbody>
<tr>
<td>Main Effects</td>
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<td>3</td>
<td>.047</td>
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</tr>
<tr>
<td>A (Program)</td>
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<td>1</td>
<td>.005</td>
<td>.166</td>
</tr>
<tr>
<td>B (Strength Level)</td>
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<td>1.916</td>
</tr>
<tr>
<td>C (Gender)</td>
<td>.076</td>
<td>1</td>
<td>.076</td>
<td>2.464</td>
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<tr>
<td>Two Way Interactions</td>
<td>.138</td>
<td>3</td>
<td>.046</td>
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<td>A x B</td>
<td>.019</td>
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<td>.019</td>
<td>.625</td>
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<tr>
<td>A x C</td>
<td>.082</td>
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<td>.082</td>
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<td>B x C</td>
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<td>1.185</td>
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<td>Three Way Interactions</td>
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<td>1</td>
<td>.022</td>
<td></td>
</tr>
<tr>
<td>A x B x C</td>
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<td>1</td>
<td>.022</td>
<td>.702</td>
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<tr>
<td>Residual</td>
<td>.864</td>
<td>28</td>
<td>.031</td>
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</tr>
</tbody>
</table>

*F = 4.20, p < .05

4. There was no significant interaction, \( F = .625 \), between training programs and initial strength level regarding strength change (\( F(1, 28) = 4.20, p < .05 \)). The means are included in Appendix C.

5. There was no significant interaction, \( F = 2.651 \), between training programs and gender regarding strength changes (\( F(1, 28) = 4.20, p < .05 \)). The means are included in Appendix C.
6. There was no significant interaction, \( F = 1.851 \), between initial strength level and gender regarding strength changes (\( F(1, 28) = 4.20, p < .05 \)). The means are included in Appendix C.

7. There was no significant interaction, \( F = .702 \), between training programs, initial strength level, and gender regarding strength changes (\( F(1, 28) = 4.20, p < .05 \)). The means are included in Appendix C.

**Initial Endurance Compared to Initial Strength**

Subjects were divided into either a high or low strength group depending on initial strength level. Along with initial strength level, the other independent variable was gender. The dependent variable was initial endurance levels. The ANOVA (Table 5) indicated the following:

1. There was no significant difference in initial endurance, \( F = 3.376 \), between those subjects with a high strength level and those with a low strength level (\( F(1, 51) = 4.04, p < .05 \)). The means were 20.7 for those with a high strength level and 32.9 for those with a low strength level.

2. There was a significant difference in initial endurance, \( F = 33.244 \), between gender (\( F(1, 51) = 4.04, p < .05 \)). The means were 28.6 for females and 25.8 for males.

3. There was no significant interaction, \( F = 1.393 \), between initial strength level and gender regarding initial
endurance ($F(1, 51) = 4.04, p < .05$). The means were 21.1 for females with a high strength level, 20.0 for males with a high strength level, 36.1 for females with a low strength level, and 29.7 for males with a low strength level.

Table 5
ANOVA Summary Table for Initial Endurance Level

<table>
<thead>
<tr>
<th>Source</th>
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<th>M.S.</th>
<th>F</th>
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<td>1127.332</td>
<td></td>
</tr>
<tr>
<td>A (Strength)</td>
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<td>1</td>
<td>218.407</td>
<td>3.376</td>
</tr>
<tr>
<td>B (Gender)</td>
<td>2150.827</td>
<td>1</td>
<td>2150.827</td>
<td>33.244*</td>
</tr>
<tr>
<td>Two Way Interaction</td>
<td>90.133</td>
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<td>90.133</td>
<td></td>
</tr>
<tr>
<td>A x B</td>
<td>90.133</td>
<td>1</td>
<td>90.133</td>
<td>1.393</td>
</tr>
<tr>
<td>Residual</td>
<td>3299.600</td>
<td>51</td>
<td>104.527</td>
<td></td>
</tr>
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</table>

*F(1, 51) = 4.04, p < .05

Discussion

Strength Changes

There was a significant difference in the amount of strength gained between training programs (Table 1). The amount of strength gained was the dependent variable. The training program and gender were the independent variables. The marginal means for each group (expressed as ratio of weight lifted to body weight) during pretesting were as follows:
(a) control males, .82; (b) control females, .50; (c) strength males, 1.01; (d) strength females, .54; (e) endurance males, 1.04; and (f) endurance females, .55. The marginal means for posttesting were as follows: (a) control males, .82; (b) control females, .50; (c) strength males, 1.16; (d) strength females, .70; (e) endurance males, 1.21; and (f) endurance females, .64.

A graph (Figure 1) was constructed to determine which program caused the significant difference. This graph showed that males and females in the control group reacted differently than those in a training program. Those who did not lift weights were not expected to increase strength (Clarke & Stull, 1970; Hunter, 1985; Kraemer & Fleck, 1988; Stull & Clarke, 1970). The other groups responded to strength testing in a similar manner. The majority of the literature reviewed supported these results (Clarke & Stull, 1970; DeLateur et al., 1968; Gillespie & Gabbard, 1984; Meadors et al., 1983; and Stull & Clarke, 1970).

Endurance Changes

There was a significant difference in the amount of endurance gained between training programs (Table 2). The endurance gained was the dependent variable. The training program and gender were the independent variables. The marginal means (number of repetitions performed) for each group during pretesting
Figure 1. Strength Changes.

were as follows: (a) control males, 18.1; (b) control females, 32.8; (c) strength males, 22.2; (d) strength females, 40; (e) endurance males, 21.5; and (f) endurance females, 23.8. The posttest were as follows: (a) control males, 19.9; (b) control females, 29.3, (c) strength males, 17.9; (d) strength females, 23.4; (e) endurance males, 21.4; and endurance females, 25.4.

A graph (Figure 2) was constructed to show which of the training programs caused the results to be significant. Some of the results were expected. Males and females in the control groups showed slight changes in endurance levels, but these changes were probably due to differences in pretesting and
posttesting. Males and females who trained for strength were expected to lose endurance (Anderson & Kearney, 1982; DeLorme, 1945; McGlynn, 1969; Noble & McCraw, 1973). Females in the strength group lost more endurance than males in the strength group. This may have been because these females had a higher initial endurance level than any other group. After training, the endurance levels for all the training groups were similar. The group gained more endurance than those who trained for strength, which was expected. Males who had trained for endurance,

Females in the endurance group however, showed a slight decrease in their endurance levels. The amount of endurance gained does seem to be related to the amount of strength gained. Since males in the endurance group gained more strength than females in the endurance group, the males did not gain as much endurance. These results were supported by DeLorme (1945), DeLorme and Watkins (1948), and Anderson and Kearney (1982). The results of all these studies indicated that subjects who gained more strength would gain less endurance.

None of the literature searched indicated that subjects might respond differently to the strength and endurance testing. The response to strength testing, regardless of training program, was fairly uniform. The response to endurance testing, however, varied a great deal with training program. In this study, the training program had a much greater effect on the subject's endurance than on his or her strength.
Changes in Strength Compared to Initial Strength

For both male and female subjects, there was no significant difference between the amount of strength gained and the initial strength level, high versus low (Table 4). The dependent variable was the amount of strength gained. The independent variables were the initial strength level, the training program, and gender. Males were included in the high strength group if their initial strength to body weight ratio was greater than .9750. Females were included in the high strength group if their strength to body weight ratio was greater than .5357. The mean strength changes (expressed in strength to body weight ratio) for each group were as follows: (a) males in the high
strength group, .1474; (b) females in the high strength group, .1503; (c) males in the low strength group, .1784; and (d) females in the low strength group, .1339.

These results conflicted with those of Hakkinen (1985), Yessis (1986), Michael and Parrish (1978), O'Shea (1966), and Jette et al. (1987). Subjects in these studies who were initially stronger gained less strength than those who were initially weaker. The results of this study may differ from the other studies due to the method used to divide subjects into high and low strength groups and to the homogeneity of the groups. There does not seem to be any definition of what constitutes high strength. Therefore, subjects in this study were divided into high and low strength groups by choosing a number that caused approximately one half of the subjects to fall into the high strength groups and the other half to fall into the low strength groups. The division was made by comparing subjects to each other, not by a defined strength level. Thus, there may not have been large enough differences between the initial strength levels of the subjects to lead to differences in strength gains.

Another possible cause for the conflicting results could have related to the length of time of this study. Over a short period of time (in this case, six weeks), there may not have been enough time for differential strength gains to occur between groups. Perhaps if this study had lasted
longer, the subjects with an initially high strength level would have gradually begun to gain strength at a slower rate than the weaker subjects. Thus, there might have eventually been a significant difference in the amount of strength gained by subjects based on initial strength level.

Michael and Parrish (1978) stated that each person has mechanical limits for the amount of strength that an individual could gain. High strength individuals, being closer to these limits than low strength individuals, would gain strength more slowly as they neared these limits. A numerical value could not be placed on these limits because all individuals would have different limits based on body type. The high strength individuals in this study, although stronger than the others in this study, may not have been near these mechanical limits.

Since none of the subjects were competitive athletes, few of them had been participating in a strict, long-term resistance training program. Significant differences may not occur between individuals of different strength levels until the high strength individuals reach a certain level of strength. It is possible that this level might only be attained through a long-term training program.

Initial Endurance Compared to Initial Strength

There was no significant difference between initial
strength level and initial endurance level (Table 5). The dependent variable was the initial endurance level. The independent variables were the initial strength level (high or low) and gender. The means (expressed as repetitions completed) were as follows: (a) males in the high strength group, 20.0; (b) males in the low strength group, 21.1; (c) females in the high strength group, 36.1; and (d) females in the low strength group, 29.7.

The findings of Berger (1964), McGlynn (1969), Noble and McCraw (1973), and Hoeger et al. (1990) conflicted with these results. These researchers found that subjects with an initially higher strength level had a lower endurance level than subjects who were initially weaker. McGlynn stated that subjects with stronger muscles fatigued faster and could not perform as many repetitions during endurance exercises.

However, Martens and Sharkey (1966) thought that the ability to perform endurance activities was dependent on having adequate muscular strength. They felt that although it was difficult to assess how initial strength and endurance interrelated because many different factors affected this interaction.

It may be that initial strength may have to be very great before it will interfere with the ability of muscles to perform muscular endurance activities. Hoeger et al. (1990) stated that increased muscle mass interfered with the ability of
muscles to remove oxygen, making endurance activities harder to perform. Subjects in this study may not have been at a high enough strength level for this interference to occur. Since the groups were divided approximately in half to form the high and low strength groups, there may not have been a great strength difference between the groups (the groups were homogeneous) to interfere with endurance levels.

**Changes in Strength Compared to Level of Experience**

There was no significant difference in the amount of strength gained according to the experience level of the subjects (Table 3). The amount of strength gained was the dependent variable. The training program, gender, and experience level (high or low) were the independent variables. The mean strength gains were as follows: (a) females with little experience, .1321; (b) males with little experience, .1755; (c) females with a high level of experience, .1126; and (d) males with a high level of experience, .1487.

These results conflicted with those of Yessis (1986) and Hakkinen (1985). Subjects who were not accustomed to resistance training gained more strength during the early stages of training due to the learning effect. These increases in strength for inexperienced lifters were attributed to neural adaptations that occurred with practice. As the neural pathways were perfected, strength gains occurred more slowly.
In this study, the learning effect may have been negligible due to the familiarity and simplicity of the bench press exercise. Even inexperienced lifters were able to perfect neural pathways quickly. Thus, very little of the initial strength gain could be attributed to the learning of the exercise. This may have been the reason that there was not a significant difference between the groups after training.

Another reason there may have not been a significant difference between the groups may have been based on the designation of experience levels and the homogeneity of the groups. Subjects were divided into experience groups according to their own indication of their experience level. These divisions were arbitrary, and thus, may have affected the statistical outcomes.

**Gender and Strength**

There was a significant difference in the amount of strength gained between genders (Table 1). However, Figure 1 showed that males and females responded the same way when looking at strength. All subjects gained approximately the same percentage of strength compared to their initial strength level. Although females did not get as strong as males, they were able to increase their strength by the same magnitude as the males. Studies (Brown & Wilmore, 1974; Capen et al.,
1961; O'Shea & Wegner, 1981) confirmed that females, when given the opportunity to lift weights, experienced strength gains similar to those of males.

**Gender and Endurance**

There was a significant difference in the amount of endurance gained or lost between genders (Table 2). Females in the endurance group gained endurance, while males in the endurance group slightly decreased their endurance. This might have been due to the intensity level of the endurance training program. These subjects may have had to lift 60% of their 1RM until fatigue in order to gain endurance (DeLateur et al., 1968). Females in the strength group lost more endurance than any other group. This may be due to their initially higher level of endurance. These differences in initial endurance levels may be attributed to the type of activities that males and females generally have performed. Females often have performed endurance type activities and have not been given as many opportunities as males to perform strength activities (Wilmore, 1974). Once the females in the strength group performed strength activities, their endurance levels became similar to those of the males. However, the reason for the differences between genders in endurance levels was difficult to determine. No studies were found that compared the endurance levels of males and females.
after resistance training (all the studies found described changes in strength levels).
CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem of this study was to compare the effects of two resistance training programs. This study compared a resistance training program designed to increase strength to one designed to increase endurance.

Fifty-five volunteers from General Physical Education classes at Western Michigan University, Kalamazoo, were divided into three groups; control, endurance training, and strength training. All subjects were pretested and posttested for strength and endurance. Subjects in the strength and endurance groups trained on the bench press three times per week for six weeks according to two different training protocols. Subjects in the strength group lifted 80 percent of 1RM for three sets of five repetitions and 90 percent of 1RM for two sets of three repetitions. Subjects in the endurance group lifted 60 percent of 1RM for three sets of 15 repetitions. Each training session followed the principle of progressive resistance. When a subject could easily complete all the repetitions required for the training program, the subject attempted a new 1RM. The weight lifted at the next training
session was then increased in accordance with the new 1RM. This process continued throughout the six weeks of the study.

Findings

The following were the findings of this study:

1. There was a significant difference in the amount of strength gained between training programs.

2. There was a significant difference in the amount of strength gained between genders.

3. There was a significant difference in the amount of endurance gained between genders.

4. There was a significant difference in initial strength between genders.

Conclusions

The following were the conclusions of this study:

1. For college-aged subjects, strength gains occur if subjects participate consistently in a training program which overloads the muscles (the amount of overload itself is not important).

2. If endurance can be increased by participating in a resistance training program, the percentage of 1RM used must be less than 60% (or strength gains will occur).

3. Males and females responded similarly to resistance training (the percentages of change was similar). However,
even after training, all the females demonstrated less strength than the males.

Recommendations

The results of this study indicated the need for more research. Studies regarding strength and endurance could also be completed for a variety of age groups, as subjects of different ages will probably respond differently to the same resistance training programs. The difference in the response of males and females to endurance training (if any) should also be studied, as most studies have only compared the strength levels of males and females. The responses to a different type of endurance training program could also be studied. Rather than increasing the weight at which the subjects trained (when they could easily complete three sets of 15 repetitions), as in this study, the number of repetitions could be increased, until the subjects could complete no more repetitions. This would show if there is a difference between endurance training programs. This may help with the standardization of resistance training terminology (if what actually constitutes endurance can be defined). This will make it easier for researchers to communicate about resistance training studies.

Exercise physiologists can use the results of this study to prescribe resistance training programs for their
participants. A LR, HR training program will not necessarily lead to increased endurance, so automatically prescribing a program of 15 repetitions for someone who only wants to increase his/her endurance may not work. When time is a consideration (which it often is for people involved in fitness programs) fewer repetitions may provide more benefits. However, each participant's fitness level must be taken into consideration when prescribing resistance training programs to insure that injuries do not occur from a participant working to close to his/her 1RM (Westcott, Greenberger, & Milius, 1989).
Appendix A

Consent Form/Information Sheet
Informed Consent

The purpose of this study is to determine the relationship between a weight training program designed to increase strength to one designed to increase endurance. Each participant in this study will be asked to perform a bench press exercise three times a week for six weeks. Each participant will be tested to find out the maximum amount they can bench press. An endurance test in which the participant lifts 60% of his/her maximum as many times as possible will also be administered. These test will be administered before and after the six week training program. The risks involved in this study are the same as those which would normally be encountered when participating in a weight training program. Every effort will be made to insure the safety of all participants. All participants are free to ask any questions which would help clarify their participation in this study.

My signature below indicates that I have been informed of the procedures involved in this study, and I have volunteered to be a participant. As a volunteer, I understand that I am free withdraw from this study at any time, without penalty. I understand that my identity will remain anonymous and that all data I produce will be confidential.

Subject's Signature _____________________________________
Information Sheet

Title of Study: A Comparison of Two Weight Training Programs on Gains in Strength and Endurance

Investigator: Pam Canavan

Contact: HPER Office, 387-2710 (leave message)

This study will compare the effects of two weight training programs on gains in strength and in endurance. Each subject will randomly be assigned to participate in either program 3 times a week for 6 weeks. The exercise involved will be the bench press. The subjects will perform either 5 sets of 5 repetitions at 90% of their maximum (for strength) or 3 sets of 15 repetitions at 60% of their maximum (for endurance). The time involved should be no more than 20-30 minutes per session. The participants in this study will agree to refrain from doing any other exercises that work the chest muscles during the 6 week period, including incline bench press, flies, push ups, and chest press. If you aren't sure whether or not an exercise works the chest muscles, please let me know.

A control group will also be needed. These subjects will be tested at the beginning and the end of the 6 weeks, but they will not bench press (or perform any of the above mentioned exercises) during the 6 weeks.

Subjects will be tested to find out how much they can bench press one time. They will also be tested for endurance by seeing how many times they can lift 60% of their maximum. The subject's weight will also be taken.

Participation in this study involves some risk. However, these risks would be similar to those normally encountered when participating when weight lifting. Every effort will be made to insure the safety of the subjects. Correct technique will be taught to every subject. Subjects will also learn correct warm-up exercises and spotting techniques. The weight room will be supervised at all times.

Your participation in this study is very much appreciated! The weight room will be open. Monday, Wednesday, and Friday from 9:00 A.M to 11:00 A.M. and from 12:00 P.M. to 12:45 P.M. You can sign up for any half hour time period, and after you have completed your bench press, you are free to use the weight room for the rest of the time! Even if you do not like to lift weights, consider being in the control group.

Thanks!
Appendix B

Human Subjects Institutional Review Board Approval
TO: Pamela S. Canavan
FROM: Ellen Page-Robin, Chair
RE: Research Protocol
DATE: January 13, 1989

This letter will serve as confirmation that your research protocol, "A Comparison of Two Weight Training Programs on Gains to Strength and Endurance," has been approved at no more than minimal risk after expedited review by the HSIRB.
Appendix C

Cell Means, Marginal Means, and Standard Deviation
## STRENGTH

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S-Strength  
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#### Initial Strength

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Low</th>
</tr>
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<tbody>
<tr>
<td>Pre</td>
<td>.8965</td>
<td>.6373</td>
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<tr>
<td>Post</td>
<td>1.0294</td>
<td>.7898</td>
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<tr>
<td>Marginal</td>
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<td>.7136</td>
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</table>

S-Strength

E-Endurance
## INITIAL ENDURANCE COMPARED TO INITIAL STRENGTH

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
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<tbody>
<tr>
<td><strong>Low Initial Strength</strong></td>
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<tr>
<td>Marginal</td>
<td>29.7</td>
<td>36.1</td>
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<tr>
<td><strong>High Initial Strength</strong></td>
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<tr>
<td>Marginal</td>
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<td>21.1</td>
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<td><strong>Gender</strong></td>
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</tr>
<tr>
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</table>
BIBLIOGRAPHY


DeLorme, T. L. (1945). Restoration of muscle power by

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training programs on the upper body strength of young women. Canadian Journal of Sport Science, 12, 71-77.


