A Comparison of Two Circuit Strength Training Programs on Strength Development of University Aged Males and Females

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ABSTRACT

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Twenty-four male and 29 female Ss were tested for strength development throughout a 2 day per week, 12 week circuit strength training program using Universal Gym equipment. Subjects were randomly divided into 2 training programs: (1) Group A -- 2 circuits of 10 reps using 75% of 1RM, and (2) Group B -- 2 circuits of 15 reps. using 50% of 1RM. Thirty seconds of work followed by 30 sec's. of rest per machine was executed. One rep. max. strength tests were performed during weeks 1, 5, 8, and 12 on the leg press and bench press. A three-way ANOVA with repeated measures was used to calculate significant differences in strength development, while a Scheffe' post hoc comparison was used to determine significant pairs of mean scores. Analysis revealed that both training programs produced significant gains in strength. Males using either training program experienced greater gains in strength than females. Irregardless of sex, neither program was significantly superior to the other in overall strength gains. Male Ss in Group A experienced a greater rate of upper body strength gain among tests than males in Group B. Group A, irregardless of sex, produced a greater rate of upper body strength development among tests than Group B.

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The candidate has completed his/her oral report.

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CHAPTER 1

INTRODUCTION

For many years, strength training was viewed as producing the "muscle-bound," "stiff," or "inflexible" trainee. It was also an area usually not pursued by females because of the fear of building muscle bulk. Today, strength training has become an integral part of most athletic conditioning programs for both sexes as well as a supplement for the recreationalist. Research has indicated that strength and/or muscular endurance increase following a strength training program (Anderson & Kearney, 1982; Fox, 1979; Gregory, 1981; Hickson, 1980; Westcott, 1982).

With more and more athletes and recreationalists turning to strength training as a means of improving performance, there becomes a need for specifically designed programs. Recent studies investigating circuit strength training have reported modest increases in strength development (Gettman, Ayres, Pollock & Jackson, 1978; Gettman, Ayres, Pollock, Durstine & Grantham, 1979; Gettman & Pollock, 1981; Gettman, Culter & Stratham, 1980; Gettman, Ward & Hagan, 1982; Wilmore, Parr & Girandola, 1978). Circuit strength training involves short periods of intense

work on weight machines alternated by short periods of rest. When complementing circuit strength training with running, swimming, or cycling for example, an increase in cardiorespiratory endurance and decrease in percent body fat may be attained (Gettman et al., 1982).

Circuit strength training may also be recommended as an off-season conditioning program for athletes, a pre-running program or a substitute for running programs for those individuals with orthopedic problems, or as a strength program for rehabilitation of injuries (Fox, 1979; Gettman et al., 1982). Other advantages to circuit training include offering an intense workout in a short period of time, ease in scheduling groups or teams in and out of the weight room, and the ability to meet the specific training needs of the individual.

From what limited research is available today, one may conclude that circuit strength training appears to be effective in increasing muscular strength, power and muscular endurance (Fox, 1979; Gettman et al., 1978; Gettman et al., 1982; Walderzak, 1984; Wilmore et al., 1978). Second, achievement of the optimal physiological benefits produced by circuit strength training depends, to a large extent, on the type of circuit set-up and the training program conducted.

Purpose of the Study

The purpose of this study was twofold. First, because circuit strength training is a relatively new area of strength conditioning, the data collected from this study was used to calculate circuit training effects on strength development of males and females. Second, the investigation compared two training prescriptions to determine the optimal combination of weightload and repetitions lifted when using circuit strength training.

Statement of the Problem

The problem of this study was designed to answer the following three questions:

1. Was there a significant difference in strength development when comparing circuit program A and circuit program B?

2. Was there a significant difference between male and female strength development when training with circuit program A or B?

3. Were there significant interaction effects in strength development among strength tests when considering circuit training programs A and B, and sex?

Need for the Study

With an increasing interest in strength training by the athelete as well as the recreationalist, there becomes

a need to compare the physiological benefits produced by various strength training programs. Related literature offers varying opinions concerning the optimal combination of weightload and repetitions for strength development. Misconceptions relative to this area of strength training have resulted in improper training methods along with the misunderstanding that one must lift heavy weightloads to gain strength. This study will attempt to answer questions regarding circuit strength training and the optimal percentage of maximum (weightload) and repetitions necessary for strength development to occur.

Hypotheses

For this study, the following null hypotheses were tested:

1. There is no significant difference in strength development when comparing circuit program A and circuit program B.

2. There is no significant difference in strength development between males and females when training with circuit program A or B.

3. There is no significant interaction effects in strength development among strength tests when considering circuit programs A and B, and sex.

Assumptions

Certain assumptions were made concerning this study:

1. The subjects were inexperienced in circuit strength training.

2. The subjects were in good health throughout the 12-week training program.

3. The subjects performed workouts and strength tests to the best of their abilities.

4. The researcher's procedures and equipment were consistent during the study.

Delimitations

This study was delimited to 24 male and 29 female college students enrolled in two beginning circuit strength training classes at the University of Wisconsin-La Crosse, spring semester, 1985.

Limitations

This study was limited by the following conditions:

1. The subject's inital level of physical fitness was not tested.

2. The subject's diet, sleep and extracurricular activities, such as strength training on non-class days, could not be controlled.

3. The subject's level of motivation to perform the workouts at 100 percent capability could not be completely

controlled.

4. Physiological adaptations to each training program could vary within individuals of the two training programs.

Definition of Terms

For the purpose of this study, the following terms were defined:

Circuit Strength Training. Interval training whereby short periods of intense work on weight machines are alternated with short periods of rest.

Circuit Training Program A. Performing 10 repetitions in 30 seconds using 75 percent of one repetition maximum (1RM) followed by a 30 second rest period.

Circuit Training Program B. Performing 15 repetitions in 30 seconds using 50 percent of one repetition maximum (1RM) followed by a 30 second rest period.

Isokinetic Contraction. A maximal muscle contraction at constant speed over the full range of movement whereby, resistance varies proportionally to the applied muscle force.

Isotonic Contraction. A muscle contraction whereby the muscle shortens as it develops varying tension through the joint angle.

One Repetition Maximum (1RM). The largest amount of weight one can lift in one repetition.

Power. The rate at which work is performed.

Repetition. One movement of an exercise through a complete range of motion.

Set. The number of repetitions performed per bout.

Specificity. The process of developing strength by exercising a muscle or muscle group involved in a particular movement or skill.

Strength Development. The ability of a muscle or muscle group to contract maximally leading to increased muscular strength. In this study, strength development refers to both the upper and lower body.

Strength Training (Weight Training). Performing various exercises, which apply resistance, to improve physical fitness or skill in a specific athletic event.

Universal Super Circuit. A conditioning program, arranged in alternating upper and lower body exercises, which promotes strength, muscle endurance, flexibility, cardiovascular efficiency, and muscular balance. The circuit in this study was set-up on the same basis.

Work. The product of a force (F) acting through a distance (d); W = F x d. For example:

Work of Group A: 75% x 10 repetitions = 750.

Work of Group B: 50% x 15 repetitions = 750.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter contains a review of literature relating to the effects of circuit strength training programs on strength development. Three subdivisions of the review of literature in circuit strength training include: (1) Introduction --- importance and relationship to physical fitness, (2) Methods of Development, and (3) Measurement.

Introduction

Participation in physical fitness activities by all age groups is increasing. Men and women have become more conscious of the importance of better health by becoming involved in activities which improve aerobic efficiency, decrease body fat, and increase strength. It is also true that people no longer view strength training as an activity just for the body builder or competitive weightlifter. Today, strength training has become a means to rehabilitate injuries, perform daily tasks and recreational activities more efficiently, and enhance one's self-image. "Weight training demonstrates, perhaps better than any other activity, the positive relationship between physical training and physiological improvement." (Westcott, 1982, p.4)

A well-designed strength training program should incorporate four basic principles: (1) muscle overload, (2) progressive resistance, (3) arrangement of exercises, and (4) specificity (Fox, 1979). Muscular strength is best developed when a muscle or muscle group is overloaded, or contracted at near maximal or maximal resistance. Resistances exceeding those normally encountered stimulate the physiological adaptations of strength development. Through progressive resistance, weightloads are periodically increased during the training program to provide adequate overload. Without progressive resistance, strengthened muscles would be underloaded, thereby only maintaining their present level of strength. Exercises should be arranged so that the larger muscle groups are exercised before the smaller ones and no two successive exercises involve the same muscle group. Because smaller muscles tend to fatigue faster, larger muscles should be exercised first to ensure proper muscle overload. By rotating the exercises that stress muscle groups, adequate recovery is allowed between lifts. And lastly, training specificity implies exercising the muscle group or movement pattern one wants to strengthen. For example, if one wants to increase strength for purposes of improving skill in the soccer kick, training should involve strengthening the muscles working through the movement patterns of the soccer kick (Fox, 1979).

Methods of Strength Development

Throughout the years, many training programs have been devised to stimulate strength development. Probably, the first systematic approach to progressive strength training was introduced by DeLorme and Watkins in the late 1940's. Progressive training was performed by lifting three sets of ten repetitions each. The first set consisted of 10 repetitions at 50 percent of one's 10RM weightload. Following this warm-up, a second set of ten repetitions at 75 percent of one's 10RM was lifted. A third and final set of 10 repetitions, performed at 100 percent of one's 10RM, became the actual stimulus for strength development. When an exercise could be performed for 15 repetitions, Delorme and Watkins recommended that a new 10 RM be established. Earlier, Delorme (1945) maintained that high resistance-low repetition exercises build strength, whereas, low resistance-high repetition exercises promote endurance.

Challenging Delorme's theory on intensity-duration training, DeLateur, Lehmann, and Fordyce (1968) tested subjects lifting high resistance-low repetition weightloads to subjects lifting low resistance-high repetition weightloads. DeLateur et al. (1968) found that those who were trained for strength gained as much endurance as those who were trained for endurance, and those who were trained

for endurance gained as much strength as those who were trained for strength.

A comparison of training three days vs. two days per week was investigated by Gregory (1981). One hundred fifty-two males, split into the two training frequencies, trained on a Universal Gym Gladiator/SR series weight machine for 16 weeks. All subjects utilized a three sets by 6-8RM strength training protocol. Significant improvements in strength occurred in all exercises for both groups. These findings were similar to those found by Berger (1962), Coleman (1977), O'Shea (1966), Pipes and Wilmore (1975), Wilmore (1974), and Withers (1970).

Although the final adjusted absolute and percentage strength gains of the three day per week group were greater than the two day training group, only two of the four test items (leg press and sitting press) produced significant differences in training three days per week. Thus, differences in strength development, consequent of two and three day per week strength training, were relatively small.

When comparing strength training one day, two days, three days, four days, and five days per week, Gillam (1981) used seventy-five male volunteer high school subjects. All groups lifted 18 sets of 1RM in the bench press for nine weeks. Significantly greater strength improvement was produced in training five days per week

than groups training less frequently. Overall, strength improvements increased as the number of training days per week increased. Consequently, Gillam concluded that the greater the frequency of training, up to five days per week, the greater the strength development.

Westcott (1974) investigated frequencies of one, two, three, and five training sessions per week. A bench press workout of 60 repetitions per week was divided into the four training groups: (1) 12 repetitions, five days per week; (2) 20 repetitions, three days per week; (3) 30 repetitions, two days per week; and (4) 60 repetitions, one day per week. The results revealed no statistically significant difference among the four training programs in terms of strength development. On the other hand, groups who trained more frequently with fewer sets tended to increase strength at a faster rate than those trained less often with more sets.

Numerous studies have been conducted to determine the optimal repetitions and sets performed per training session. The earliest research by Berger (1956) compared strength development in groups lifting 2RM, 6RM, and 10RM for three sets. No significant differences were recorded after five weeks of training.

In an attempt to determine the optimum number of repetitions for the quickest strength development, Berger (1962a) tested 199 male college students training in one

of the following groups: 2RM, 4RM, 6RM, 8RM, 10RM, and 12RM. One set, three days per week, for 12 weeks was executed. More sets were not employed because of the possibility of interaction between repetitions and sets. Results indicated that lifting between three and nine repetitions for one set was the most beneficial.

A third study by Berger (1962b) tested nine different strength training programs for strength development. For 12 weeks, three days per week, subjects trained on the bench press lift. Programs incorporating one, two and three sets, and two, six, and ten repetitions per set were evaluated. The maximum rate of strength development resulted from training with a 6RM for three sets. Berger also witnessed that programs with as few as two repetitions per set for one set was feasible "where minimum energy expenditure and consequent fatigue from weight training are important factors . . . ."

Circuit Strength Training

Fewer studies are available as to the effects of circuit strength training on strength development. The majority of circuit training research has reported improvements in leg press and bench press strength ranging from seven percent to 27 percent and eight percent to 32 percent respectively. Research conducted by Gettman and associates since 1978 has provided most of the information available today.

Gettman et al. (1978) studied the effects of circuit strength training on adult men. Ten exercises performed in two sets of 15 repetitions with a 20 to 25 second rest between exercises was conducted during a three day per week, 20 week program. Using Universal Gym equipment, subjects worked at approximately 50 percent of their 1RM. The results found an average weight resistance increase of 12 percent, a total weight resistance per workout increase of 81 percent, and an average weight increase from 42 percent to 56 percent of max 1RM strength. It was concluded that circuit strength training is an effective means to improve strength.

In 1979, a second study by Gettman et al., concerning the physiological effects of circuit strength training on adult men, was conducted. Subjects generally followed the same exercise protocol as the first study, but trained on isokinetic weight machines rather than isotonic. Similar strength gains were reported whether subjects were tested on isokinetic or isotonic machines.

In 1980, Gettman et al. compared the effects of a 20 week isotonic and slow-speed isokinetic circuit strength training program. Subjects completed two circuits of 12 repetitions with 30 seconds of rest between each work station. Weightloads consisting of 50 percent of 1RM was used. Total work increased significantly in both groups; the isotonic group increased an average of 5.9

to 7.6 weight units per exercise while the isokinetic group increased an average of 3870 to 4160 ft. lbs. per exercise. In contrast to the previous study, strength improvements were found to be specific to the equipment used for testing.

When comparing the effects of a combined run-circuit strength training group to that of circuit strength training alone, Gettman et al. (1982) found both programs to be effective in improving measures of physical fitness. Circuit strength training consisted of three circuits of 10 exercises, lifting 12-15 repetitions, in 30 seconds, at 40 percent of 1RM. The circuit training group rested 15 seconds between stations, while the run-circuit strength training group ran for 30 seconds between stations. Following 20 weeks of training, three days per week, strength increased 22 percent and 21 percent for the male run-circuit strength training group and circuit strength training group respectively. Females increased 22 percent and 19 percent for the run-circuit strength training group and circuit strength training group respectively.

In the preceeding study, significant strength improvement resulted from exercise sessions of 22.5 minutes and 30 minutes. No injuries were reported, and minimal muscle soreness was experienced only in the first week of training. Since the majority of investigations have reported similar training protocols and results, circuit

strength training could be used as a general conditioning, pre-running, or rehabilitation type program.

Wilmore et al. (1978) investigated physiological changes of a 10 week circuit training program in males and females. Three circuits of ten isotonic exercises were performed three days per week. Subjects lifted 40 to 55 percent of their 1RM, performing as many repetitions as possible, during a 30 second workbout. Male subjects significantly improved strength for four of eight lifts, while female subjects significantly improved for all lifts. Final strength changes of men were found to be of smaller magnitude than would be expected based on previous research.

Measurement of Strength Development

Throughout the years, many methods have been used to measure strength development, but whichever method is chosen, certain principles need to be considered. First, it is imperative that joint angle be held constant, and that only the muscle group(s) tested be allowed to contribute to the tension exerted. Second, maximal force developed during strength testing may be influenced by behavioral factors such as motivation, emotional state, etc., as well as by physiological factors such as muscle dimensions and nutritional state (Ika & Steinhaus, 1961).

Berger (1962c) suggested that no significant correlation exists between isotonic and isometric strength gains, and that values of absolute strength measured by the two methods may not correlate highly. Second, although maximum isometric strength tests are done easily, quickly, and fairly precisely, it is questionable as to the extent this procedure measures the same elements of the contractile mechanism as are required in application of force during isotonic muscle work.

Falls (1968) suggested that since isometric strength tests are less time consuming and less fatiguing than isotonic tests, isometrics offer some advantages over isotonic testing. On the other hand, Falls also indicated that isotonic tests measure strength through a complete range of motion. DeVries (1974) agrees that isometric strength measurement is less time consuming and is accomplished much easier. Second, isotonic tests may take several trials, causing the subject to fatigue, which can influence the maximum attained.

The majority of testing methods have included the use of the one repetition maximum, or 1RM, described by Berger (1962b). The maximum weightload a subject could lift was determined by increasing the load by ten pounds, or graded increments where appropriate, after each successful lift until a failing attempt was perceived. The load was then increased by five pounds until the maximum

was obtained. Subjects rested two to three minutes between attempts to account for fatigue.

Less frequently, strength has been measured by a test of "breaking" strength, which is actually a measure of maximum force in an eccentric contraction. A dynamometer records the muscular force needed to overcome a progressively increased outer resistance.

In order to examine the specificity principle, Pipes and Wilmore (1975) tested strength development in two groups of men using constant resistance and variable resistance training methods. The variable resistance group produced significantly greater strength gains when tested on variable resistance equipment, whereas, the constant resistance group produced significant increases over the variable resistance group when measured on constant resistance equipment.

Gettman et al. (1980) confirmed the results found by Pipes et al. (1975) when comparing the effects of isotonic and slow-speed isokinetic circuit strength training through a 20 week program. An 18 percent increase in strength was found for the isotonic group using the isotonic test compared to a 10 percent increase for the isokinetic group. In the isokinetic test, the isokinetic group improved 42 percent, while the isotonic group increased 17 percent. Thus, strength improvements seem to be specific to the equipment used during training and testing.

Selection of the bench press and leg press have been shown to be a valid and reliable measure of upper and lower body muscle function (Berger, 1962c; Jackson, Watkins & Patton, 1980). Both methods are also familiar to subjects, easily administered, and involve a minimum amount of skill to perform correctly.

Summary

Research results support the hypothesis that strength increases as a result of a systematic training program of lifting progressively heavier weightloads. In the broadest sense, strength increases are best produced from a program of three sets of 6-8RM, three days per week (Berger, 1962b; Berger & Hardage, 1967; DeLorme, 1945; Peterson, 1961).

Circuit strength training seems to offer some advantages over conventional training programs, including its use as a general conditioning and rehabilitation type program, along with obtaining an effective workout in a short period of time.

In determining the frequency of training per week, research has indicated varying results. Training programs from one to five days per week have reported significant strength gains, although an optimal frequency may be three days per week.

Measurement of strength development may best be determined by a 1RM test. Second, muscle function tends to be specific to the testing device used.

CHAPTER 3

METHODS

The problem of this study was to compare the effects of two circuit strength training programs on strength development. The procedures used to research this problem are divided into the following sections: subject selection, orientation of subjects, testing procedures, training programs, and statistical analysis.

Subject Selection

Subjects were 24 male and 29 female students registered in two sections of Physical Education 100, Beginning Circuit Strength Training, at the University of Wisconsin-La Crosse, spring semester, 1985. The classes met for a fifty-minute period (1:00 and 2:00 p.m.), two days per week (Tuesday and Thursday). After the researcher explained all procedures, potential risks, and benefits, each subject was asked to sign an informed consent form (Appendix A). Subjects were also asked to drop the class if they had any cardiovascular or orthopedic problems, or if they did not consider themselves a beginner. Subjects in each section were randomly divided into two training groups by use of a table of random numbers.

Orientation of Subjects

During the first two weeks of the study, subjects were instructed as to what would be expected of them throughout the entire program. All training and testing methods were outlined and demonstrated during the first and second class periods. The first two weeks enabled the subjects to adjust to the near maximal exertion required by strength training, thereby reducing the influence of prior practice and/or learning.

Testing Procedures

Testing methods included the bench press and squat press for strength development. Jackson et al. (1980) found the bench and leg press as the most valid individual measures of upper and lower body strength, respectively. The bench press utilizes three major muscle groups, the pectoralis major, the anterior deltoids, and the triceps. The leg press, as well as the squat press, work the buttocks and lower back, quadriceps, and the hamstrings. With the unavailability of a Universal leg press in this circuit and for reasons of training specificity of muscles by weight machines, the squat press was used to measure lower body strength development.

One repetition maximum (1RM) strength tests were utilized on the bench press and squat press. Testing occurred during the first week (pre-training), fifth week,

eighth week, and twelfth week (post-training) of the semester. All strength tests were conducted in the same location that training occurred. After a brief warm-up consisting of stretching and lifting three repetitions at a light weightload, the subjects lifted approximately 80 percent of their 1RM, one repetition. This procedure was then graduated, enabling the subject to lift the maximum amount of weight during the second or third repetition.

Bench Press

The bench press was performed by each subject in a supine position on the bench with feet flat on the floor, or on top of the bench. Using the overhand grip, the subject raised the bar vertically until arms were fully extended, and returned to the starting position.

Squat Press

The squat press was performed with feet shoulder width apart, standing either on the machine's platform, or on an elevated platform depending upon the height of the subject. Using the overhand grip and with the back straight, the weight stack was lifted to full extension, lowered to approximately 90 degrees flexion of the legs, then raised to full extension.

Training Programs

The subjects participated in a 12 week progressive resistance circuit strength training program. The bench press and squat press weightloads were held constant until new training weightloads were calculated following each 1RM strength test. An example circuit consisted of 14 exercises in the following order:

1. Overhead press
2. Leg squat
3. Abdominal board
4. Bench press
5. Knee extension
6. Lat pulldowns
7. Vertical chest
8. Hip abduction (R)
9. Hip abduction (L)
10. Knee flexion
11. Upright row
12. Tricep extensor
13. Bicep curl
14. Stationary bike

Students began each training session at a different machine to equalize muscular stress and specific strength development.

Training protocols for both Group A and Group B were selected on the basis of past research involving strength training and the optimal weightload and repetitions needed for strength development.

Group A

Each subject in Group A performed two circuits of 8-10 repetitions at 75 percent of 1RM in 30 seconds followed by a 30 second rest interval. When a subject

could perform more than 10 effortless repetitions during both circuits, the weightload was increased by one weight plate.

The majority of today's isotonic programs follow the general principles set forth by DeLorme and Watkins in the late 1940's. The 10RM weightload is generally considered to be 75 percent of one's 1RM. DeLorme and Watkins found weightloads approximately 75 percent of 1RM to be the most effective in promoting strength gains.

Group B

Each subject in Group B performed two circuits of 13-15 repetitions at 50 percent of 1RM in 30 seconds followed by a 30 second rest period. When a subject could perform more than 15 effortless repetitions during both circuits, the weightload was increased by one weight plate.

Research by Gettman et al. (1978) indicated that repetitions greater than 15 and an intensity greater than 50 percent maximum strength could not be tolerated by subjects attempting to complete a 22.5-30 minute circuit strength training program.

Statistical Analyses

Data obtained in this study was analyzed on a Digital Equipment Corporation VAX 11/780 computer using the Statistical Package for the Social Sciences Extended (SPSSX

Incorporated, 1983). The hypotheses were tested by a three-way analysis of variance design (group x set x tests) with repeated measures on the third factor. A Scheffe' post hoc comparison was also used to determine which pairs of means were significantly different. The .05 level of significance was chosen to test the hypotheses of the study.

CHAPTER 4

RESULTS AND DISCUSSION

The purpose of this study was to collect data on circuit training effects on strength development of males and females, and to compare two training programs utilizing different weightloads and repetitions. Two groups were involved: Group A performed two circuits of 15 repetitions using 50 percent of 1RM. Thirty-seconds of work followed by 30 seconds of rest at each station was employed.

All subjects executed 1RM strength tests during the first, fifth, eighth, and twelfth week of training. Assessment of upper body strength was determined by the bench press, while lower body strength was determined by the squat press. Table 1 presents the physical characteristics of the subjects.

Table 1

Physical Characteristics of Subjects
(age, body weight)

Sex	Variable	Mean	Std. Dev.	Range
Male N=22	Age (yrs)	21.0	2.0	19-29
	Weight (lbs)	176.3	17.2	143-224
Female N=29	Age (yrs)	21.8	2.5	18-33
	Weight (lbs)	130.2	18.2	105-183

Analysis of Variance

A three-way analysis of variance with repeated measures was used to calculate F-statistics to determine if there were significant differences in strength development between the two training groups, sex, and strength tests (2 x 2 x 4). If a significant F-ratio was obtained for strength development among tests, the Scheffe' post hoc comparison was used to determine which pairs of means were significantly different. Tables showing the mean scores and differences of the bench press and squat press are presented for each variable. A summary table of analysis of variance with repeated measures and levels of significance are also shown for each variable.

Analysis results related to this study are discussed separately under the following headings: (1) Squat Press--Sex + Training Program, (2) Bench Press--Sex + Training Program, (3) Squat Press--Males Only, (4) Bench Press--Males Only, (5) Squat Press--Females Only, and (6) Bench Press--Females Only.

Squat Press--Sex + Training Program

Four lower body strength tests were administered to each subject. Table 2 presents a comparison of sex and training program test means and ranges for the squat press strength test.

Table 2

A Comparison of Test Means and Ranges
for the Squat Press Strength Test (lbs)

	Grp. A		Grp. B		Marginal
	Male	Female	Male	Female	
Squat 1	314.20	183.27	307.80	176.17	235.81
Squat 2	342.70	233.33	332.50	216.25	273.34
Squat 3	411.80	252.60	404.20	238.92	315.23
Squat 4	422.80	278.67	426.90	259.17	335.89
Marginal	372.88	236.97	367.85	222.63	290.07
Range	108.60	95.40	119.10	83.00	100.08
N	10	15	10	12	47

The results presented show a large increase in squat press strength for both sex and training group variables. The larger increase in strength for males resulted from Program B, while females produced a greater increase in strength from Program A. The results of an analysis of variance which tested the difference in strength development in each treatment for significance is presented in Table 3.

Table 3

A Summary of Analysis of Variance for the Squat Press Strength Test

Source	df	Mean Square	F	Tail Prob.
Group	1	4286.49	1.14	.2918
Sex	1	903268.01	240.01*	.0000
Grp./Sex	1	992.00	.26	.6103
Error	43	3763.46		
R	3	95387.73	246.93*	.0000
RG	3	110.95	.29	.8346
RS	3	5952.93	15.41*	.0000
RGS	3	280.61	.73	.5380
Error	129	386.30		

*$p < .05$

Results of the analysis of variance for the squat press strength test revealed a significant difference in strength development between sexes---irregardless of the training program, but not between training groups. A repeated measures test verified the significance between sexes (RS). Figure 1 illustrates the changes in strength development between sexes throughout the four squat press strength tests.

Fig. 1. Male vs. Female Squat Press Strength Development

● = Males/Grp. A
✳ = Males/Grp. B
\+ = Females/Grp. A
Δ = Females/Grp. B.

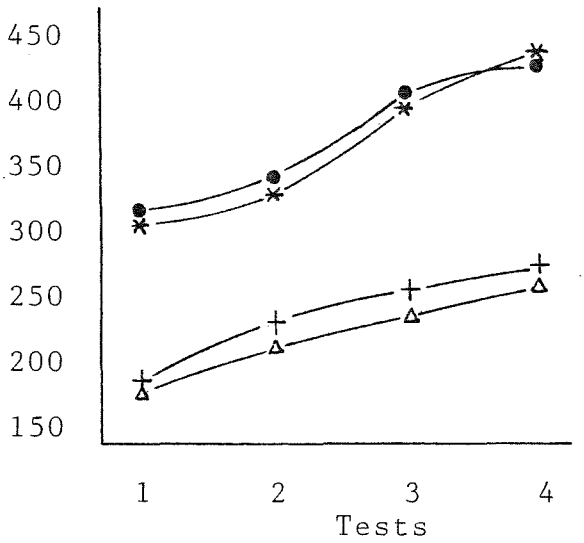


Figure 1 illustrates a slightly greater increase (steeper slope) in strength development in the squat press for both male training groups when compared to the female training groups.

The observed F in the repeated measures test (R) indicated a significant increase in strength among the four tests. Results of the Scheffe' post hoc comparison revealed a significant F between pairs of mean scores for each squat press strength test when combining sex and training program. This data may be examined in Appendix E.

Bench Press--Sex + Training Program

Four upper body strength tests were administered to each subject. Table 4 provides a comparison of sex and training program test means and ranges for the bench press strength test.

Table 4

A Comparison of Test Means and Ranges
for the Bench Press Strength Test (1bs)

	Grp. A		Grp. B		Marginal
	Male	Female	Male	Female	
Bench 1	149.91	63.00	146.45	63.29	99.82
Bench 2	168.55	71.00	158.73	68.43	110.25
Bench 3	176.55	79.40	165.55	76.14	118.04
Bench 4	184.27	85.60	170.55	82.14	124.25
Marginal	169.82	74.75	160.32	72.50	113.09
Range	34.36	22.60	24.10	18.85	24.43
N	11	15	11	14	51

Examination of the mean differences suggested a substantial increase in bench press strength for both sex and training program variables. The larger increase in strength for both males and females resulted from training program A. An analysis of variance which tested the difference in strength development in each treatment for significance is shown in Table 5.

Table 5

A Summary of Analysis of Variance for the Bench Press Strength Test

Source	df	Mean Square	F	Tail Prob.
Group	1	1726.25	.82	.3075
Sex	1	418205.93	198.05*	.0000
Grp./Sex	1	657.21	.31	.5796
Error	47	2111.60		
R	3	5794.30	281.46*	.0000
RG	3	114.47	5.56*	.0012
RS	3	228.80	11.11*	.0000
RGS	3	22.59	1.10	.3524
Error	141	20.59		

*$p < .05$

A review of the data indicated a significant difference in bench press strength development between sexes---irregardless of the training program, but not between training groups. A repeated measures test verified the significance between sexes (RS), and also showed a slight significance between groups (RG). Figure 2 shows the changes in strength development between sexes throughout the four bench press strength tests.

Fig. 2. Male vs. Female Bench Press Strength Development

● = Males/Grp. A
* = Males/Grp. B
+ = Females/Grp. A
△ = Females/Grp. B

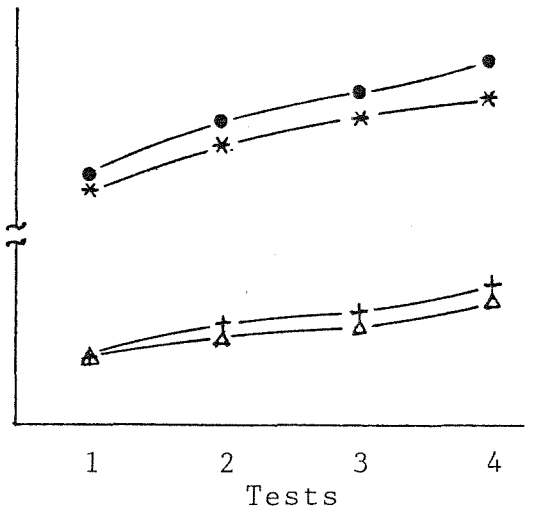
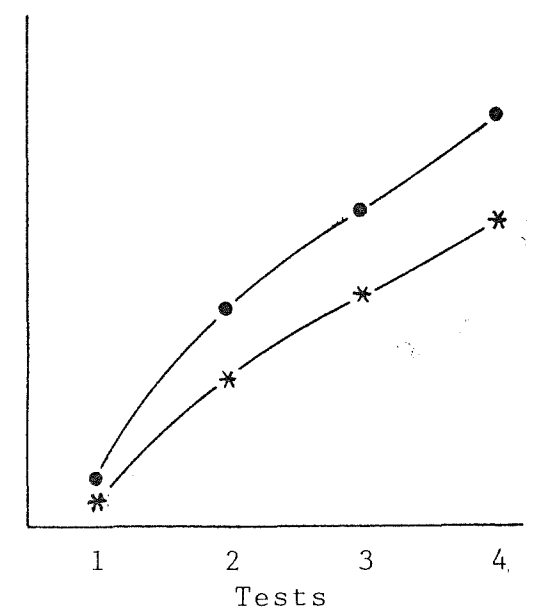


Figure 2 shows a slightly greater increase (steeper slope) in bench press strength development for both male training groups when compared to the female training groups.

Figure 3 shows the changes in bench press strength development between groups---irregardless of sex, throughout the four strength tests.

Fig. 3. Grp. A vs. Grp. B Bench Press Strength Development

● = Grp. A
* = Grp. B



The slopes of the lines in Figure 3 verify the significance found between groups (RG) for the four bench press strength tests.

The observed F in the repeated measures test (R) also indicated a significant increase among strength tests. Results of the Scheffe' post hoc comparison revealed a significant F between pairs of mean scores for each bench press strength test when combining sex plus training program. This data may be examined in Appendix F.

Squat Press--Males Only

Male subjects were tested for lower body strength development on four different occasions. Table 6 presents a comparison of male training program test means and ranges for the squat press strength test.

Table 6

A Comparison of Male Test Means and Ranges for the Squat Press Strength Test

	Grp. A	Grp. B	Marginal
Squat 1	314.20	307.80	311.00
Squat 2	342.70	332.50	337.60
Squat 3	411.80	404.20	408.00
Squat 4	422.80	426.90	424.85
Marginal	372.88	367.85	370.36
Range	108.60	119.10	113.85
N	10	10	20

The preceeding results show a large increase in male squat press strength development for both training groups. The slightly larger increase in strength resulted from Program B. An analysis of variance which tested the difference in strength development in each treatment for significance is presented in Table 7.

Table 7

A Summary of Analysis of Variance for the Male Squat Press Strength Test

Source	df	Mean Square	F	Tail Prob.
Group	1	505.01	.19	.6667
Error	18	2634.15		
R	3	59885.05	133.77*	.0000
RG	3	197.61	.44	.7243
Error	54	447.68		

*p<.05

Results of the analysis of variance for the male squat press strength test revealed no significant difference in strength development between groups.

The observed F in the repeated measures test (R) indicated a significant increase in lower body strength among the four tests. Results of the Scheffe' post hoc comparison revealed significant increases in strength

between mean scores on all tests except for a nonsignificant F between tests three and four. Data may be examined in Appendix G.

Bench Press--Males Only

Four upper body strength tests were administered to each male subject. Table 8 provides a comparison of male training program test means and ranges for the bench press strength test.

Table 8

A Comparison of Male Test Means and Ranges for the Bench Press Strength Test (lbs)

	Grp. A	Grp. B	Marginal
Bench 1	149.91	146.45	148.18
Bench 2	168.55	158.73	163.64
Bench 3	176.55	165.55	171.05
Bench 4	184.27	170.55	177.41
Marginal	169.82	160.32	165.07
Range	34.36	24.10	29.23
N	11	11	22

The ranges indicated a significant increase in male upper body strength by both training groups, with Group A having the greater gain. An analysis of variance which tested the difference among the gains experienced in each treatment for significance is presented in Table 9.

Table 9

A Summary of Analysis of Variance
for the Male Bench Press Strength Test

Source	df	Mean Square	F	Tail. Prob.
Group	1	1985.50	.45	.5109
Error	20	4431.48		
R	3	3484.98	127.86*	.0000
RG	3	104.08	3.82*	.0143
Error	60	27.26		

*$p < .05$

While no significant difference was found between the two training groups, the observed F in the repeated measures test indicated a significance among upper body strength tests (R) and also between groups among tests (RG). Figure 2 (page 34) shows the changes in male upper body strength development. The Scheffe' post hoc test showed a significant F between each pair of male bench press strength test means. Data from the Scheffe' test can be examined in Appendix H.

Squat Press--Females Only

Female subjects were tested for lower body strength development on four different occasions. Table 10 presents

a comparison of female training program test means and ranges for the squat press strength test.

Table 10

A Comparison of Female Test Means and Ranges for the Squat Press Strength Test (lbs)

	Grp. A	Grp. B	Marginal
Squat 1	183.27	176.17	180.11
Squat 2	233.33	216.25	225.74
Squat 3	252.60	238.92	246.92
Squat 4	278.67	259.17	270.00
Marginal	236.97	222.63	230.59
Range	95.40	83.00	89.89
N	15	12	27

Both female training groups seemed to experience considerable lower body strength development. Table 11 presents a summary of the analysis of variance for the female squat press strength test.

Table 11

A Summary of Analysis of Variance for the Female Squat Press Strength Test

Source	df	Mean Square	F	Tail Prob.
Group	1	5484.89	1.20	.2841
Error	25	4576.58		
R	3	38384.05	112.20*	.0000
RG	3	193.33	.57	.6397
Error	75	342.10		

*p<.05

The F obtained in the analysis of variance indicated a significant difference among the four strength tests (R), but not between groups. The results of the Scheffe' post hoc test showed a significant F value between means on each test. Data from the Scheffe' test may be reviewed in Appendix I.

Bench Press--Females Only

Four upper body strength tests were administered to each female subject. Table 12 provides a comparison of female training program test means and ranges for the bench press strength test.

Table 12

A Comparison of Female Test Means and Ranges for the Bench Press Strength Test (lbs)

	Grp. A	Grp. B	Marginal
Bench 1	63.00	63.29	63.14
Bench 2	71.00	68.43	69.76
Bench 3	79.40	76.14	77.83
Bench 4	85.60	82.14	83.93
Marginal	74.75	72.50	73.66
Range	22.60	18.85	20.79
N	15	14	29

Both training groups appear to have improved upper body strength with Group A increasing the most. Table 13 contains a summary of analysis of variance for the female press strength test.

Table 13

A Summary of Analysis of Variance for the Female Bench Press Strength Test

Source	df	Mean Square	F	Tail Prob.
Group	1	146.64	.37	.5465
Error	27	393.17		
R	3	2388.22	152.63*	.0000
RG	3	21.74	1.39	.2521
Error	81	15.65		

*$p < .05$

No significant difference in strength development was found between female training groups, but the observed F in the repeated measures analysis indicated a significance among upper body strength tests (R). A Scheffe' post hoc comparison showed a significant F between mean scores on each female bench press strength test. Data from the Scheffe' comparison can be examined in Appendix J.

Discussion

Both male and female subjects, trained by either circuit strength training program, experienced significant

strength development following this 12-week session. Second, when combining sex plus training program, neither training program was statistically superior to the other in causing overall strength development. Thus, if using circuit training program A or B in combination with the overload principle, significant strength development may occur.

If combining sex plus training program, a statistically significant difference occurred in the rate of strength development between sexes. Upper body and lower body male strength development---irregardless of training program, was significantly greater than female strength development. Gettman et al. (1982) found a 21 percent increase in strength for males and a 19 percent increase for females in a 20 week circuit strength training program.

A statistically significant difference in the rate of upper body strength development also occurred among strength tests and between groups---irregardless of sex. Training Group A (males plus females) experienced greater upper body strength development among tests than training Group B.

When only comparing males and the two training groups, training Group A produced a significantly greater rate of strength gain among tests on the bench press than did Group B.

Although not statistically significant, a greater range of strength development from pretest to post-test occurred in the following conditions: (1) Male upper body strength development = Training Program A, (2) Male lower body strength development = Training Program B, (3) Female upper body strength development = Training Program A, and (4) Female lower body strength development = Training Program A. Possible reasons for number two occurring include the subject's diet, previous nights sleep before strength test four, mathematical error, or strength testing errors.

From the data presented in this study, it is apparent that circuit strength training causes an increase in strength development, with similar gains produced by either program. It is also interesting to note that significant strength gains were reported among all tests, for both sexes, with the exception of a nonsignificant gain between tests three and four for the male squat press test. The increases in strength found in this study are supported by other researchers such as Gettman et al. (1978), Gettman et al. (1980), Gettman & Pollock (1981), Gettman et al. (1982), Wilmore (1974), and Wilmore et al. (1978).

The null hypothesis for this study stated that there would be no significant difference in strength development between training programs, between sexes, and in the interaction effects among strength tests when combining sex and training program variables.

The null hypothesis was accepted when comparing training programs, and the interaction effects among strength tests. The alternative hypothesis was accepted when comparing male versus female strength development.

CHAPTER 5

SUMMARY, RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The purpose of this investigation was to compare the effects of two beginning circuit strength training programs on strength development. Twenty-four male and 29 female subjects trained two days per week, for 12 weeks, at the University of Wisconsin-La Crosse spring semester, 1985. Subjects were randomly divided into Training Program A or Training Program B. Program A consisted of lifting 10 repetitions in 30 seconds using 75 percent of 1RM followed by a 30 second rest interval. Program B consisted of lifting 15 repetitions in 30 seconds using 50 percent of 1RM followed by a 30 second rest interval. Both groups performed two circuits per day.

One repetition maximum strength testing occurred during the first week (pretraining), fifth week, eighth week, and twelfth week (post-training) of the semester. Upper body strength development was determined by the bench press, while lower body strength development was determined by the squat press.

Data from this study was analyzed by a three-way analysis of variance (group x sex x tests) with repeated

measures on the third factor. The Scheffe' post hoc comparison was used to determine which pairs of means were significantly different.

Results

Based on the limitations of this study, the following results were reported:

1. Both training programs produced significant increases in strength development in males and females.

2. Male subjects produced greater increases in upper and lower body strength development than female subjects.

3. Irregardless of sex, neither training program was statistically superior to the other in final strength gains.

4. Training Group A--irregardless of sex, produced a greater rate of upper body strength development than Group B.

5. Male subjects training with Program A experienced a greater rate of upper body strength development among strength tests than did males in Group B.

6. With the exception of a nonsignificant increase in strength development between tests three and four for the male squat press test, significant increases in strength were reported between all other pairs of means tested for the bench press and squat press.

Conclusions

Based on the hypotheses which were tested, the following conclusions can be made:

1. Both circuit strength training programs will produce significant as well as similar increases in strength.

2. When using either circuit strength training program, males will experience greater increases in upper and lower body strength development than females.

3. In the majority of cases and when applying the overload principle, significant increases in strength --- irregardless of sex, will occur repeatedly among strength tests.

4. Participants training with Program A will experience a greater rate of upper body strength development among tests than training with Program B.

5. Males training with Program A will experience a greater rate of upper body strength development among tests than training with Program B.

Recommendations

As a result of this investigation, the following recommendations are made:

1. A similar study using the same training programs, but also measuring changes in body composition, heart

rate, aerobic capacity, and perceived exertion, should be conducted.

2. Research should be performed in the area of attitudes and perceived exertions of beginner circuit strength trainee's and whether lifting lighter weightloads with more repetitions would be preferred.

3. A study should be conducted to determine whether lifting lighter weightloads with more repetitions is superior to lifting heavier weightloads with less repetitions for male lower body strength development.

4. Further study should be done to compare the squat press 1RM test to the leg press 1RM test for determining lower body strength.

5. Further study should be performed to determine the effect of circuit strength training on older subjects, subjects with various orthopedic problems, cardiac patients, and circuit strength trainings effectiveness as a preseason athletic training program.

REFERENCES CITED

REFERENCES CITED

Anderson, T., & Kearney, J. (1982). Effects of Three Resistance Training Programs on Muscular Strength and Absolute and Relative Endurance. Research Quarterly, 53, 1-7.

Berger, R. (1956). The effects of selected progressive resistance exercise programs on strength, hypertrophy, and strength development. Unpublished master's thesis, Michigan State University, Michigan.

Berger, R. (1962a). Optimum repetition for the development of strength. Research Quarterly, 33, 334-348.

Berger, R. (1962b). Effect of varied weight training programs on strength. Research Quarterly, 33, 168-181.

Berger, R. (1962c). Comparison of Static and Dynamic Strength Increases. Research Quarterly, 33, 329-333.

Berger, R. & Hardage, B. (1967). Effect of maximum loads for each of ten repetitions on strength improvement. Research Quarterly, 38, 715-718.

Coleman, A. (1977). Nautilus vs. universal gym strength training in adult men. American Corrective Therapy Journal, 31, 103-107.

DeLateur, B., Lehmann, J., & Fordyce, W. (1968). A test of the DeLorme axiom. Archives of Physical Medicine and Rehabilitation, 49, 245-248.

DeLorme, T. (1945). Restoration of muscle power by heavy resistance exercise. Journal of Bone and Joint Surgery, 27, 645-667.

DeLorme, T. & Watkins, A. (1978). Techniques of progressive resistance exercise. Archives of Physical Medicine, 29, 263-273.

DeVries, H. (1974). Physiology of Exercise for Physical Education and Athletics (3rd ed.). Dubuque: W.M.C. Brown Co.

Falls, H. (1968). Exercise Physiology. New York: Academic Press.

Fox, E. (1979). Sports Physiology. Philadelphia: Saunders College.

Gettman, L., Ayres, J., Pollock, M., & Jackson, A. (1978). The effect of circuit weight training on strength, cardiorespiratory function, and body composition of adult men. Medicine and Science in Sports and Exercise, 10, 171-176.

Gettman, L., Ayres, J., Pollock, M., Durstine, L., & Grantham, W. (1979). Physiologic effects on adult men of circuit strength training and jogging. Archives of Physical Medicine and Rehabilitation, 60, 115-120.

Gettman, L., Culter, L., & Stratham, T. (1980). Physiologic changes after 20 weeks of isotonic vs. isokinetic circuit training. Journal of Sports Medicine, 20, 265-272.

Gettman, L. & Pollock, M. (1981). Circuit weight training: a critical review of its physiological benefits. Physician and Sports Medicine, 9, 44-60.

Gettman, L., Ward, P., & Hagan, R. (1982). A Comparison of Combined Running and Weight Training with Circuit Weight Training. Medicine and Science in Sports and Exercise, 14, 229-234.

Gillam, G. (1981). Effects of frequency of weight training on muscle strength enhancement. Journal of Sports Medicine, 21, 432-436.

Gregory, L. (1981). Some observations on strength training and assessment. Journal of Sports Medicine, 21, 130-137.

Hickson, R. (1980). Interference of Strength Development by Simultaneously Training for Strength and Endurance. European Journal of Applied Physiology, 45, 255-263.

Ikai, M. & Steinhaus, A. (1961). Some Factors Modifying the Expression of Human Strength. Journal of Applied Physiology, 16, 157-163.

Jackson, A., Watkins, M., & Patton, R. (1980). A factor analysis of twelve selected maximal isotonic strength performances on Universal Gym. Medicine and Science in Sports and Exercise, 12, 274-277.

O'Shea, P. (1966). Effects of selected weight training programs on the development of strength and muscle hypertrophy. Research Quarterly, 37, 95-102.

Peterson, F. (1961). The effect of varying the number of muscle contractions on dynamic muscle training. Internationale Zeitschrift fur Angewandte Physiologie Einschliesslich Arbeitphysiologie, 18, 468-473.

Pipes, T. & Wilmore, J. (1975). Isokinetic vs. isotonic strength training in adult men. Medicine and Science in Sports and Exercise, 7, 262-274.

Walderzak, P. (1984). Super Circuit Training. National Strength and Conditioning Association Journal, 6, 38-40.

Westcott, W. (1974). Effects of varied frequencies of weight training on the development of strength. Master's thesis, Pennsylvania State University, Pennsylvania.

Westcott, W. (1982). Strength Fitness. Allyn and Bacon, Inc.

Wilmore, J. (1974). Alterations in strength, body composition, and anthropometric measurement consequent to a 10 week weight training program. Medicine and Science in Sports and Exercise, 6, 133-138.

Wilmore, J., Parr, R., & Girandola, R. (1978). Physiological alterations consequent to circuit weight training. Medicine and Science in Sports and Exercise, 10, 79-84.

Withers, R. (1970). Effect of varied weight training loads on the strength of university freshmen. Research Quarterly, 41, 110-14.

APPENDICES

APPENDIX A

GROUP A -- SQUAT PRESS STRENGTH TEST RESULTS

GROUP A -- SQUAT PRESS TEST RESULTS

N	SEX	TEST 1	TEST 2	TEST 3	TEST 4
1	M	334	344	389	399
2	M	299	344	388	376
3	M	253	334	372	344
4	M	334	350	434	444
5	M	276	334	434	450
6	M	322	334	388	434
7	M	311	334	388	INJURED
8	M	334	350	434	444
9	M	334	354	434	444
10	M	322	334	411	444
11	M	334	349	434	449
12	F	162	242	265	288
13	F	230	242	253	276
14	F	153	219	230	253
15	F	139	173	185	196
16	F	196	230	242	299
17	F	173	253	276	299
18	F	230	276	288	311
19	F	208	276	299	334
20	F	230	253	265	288
21	F	150	242	276	334
22	F	196	288	334	334
23	F	208	253	276	288
24	F	196	208	242	253
25	F	139	173	173	219
26	F	139	172	185	208

APPENDIX B

GROUP B -- SQUAT PRESS STRENGTH TEST RESULTS

GROUP B -- SQUAT PRESS TEST RESULTS

N	SEX	TEST 1	TEST 2	TEST 3	TEST 4
1	M	334	344	434	444
2	M	276	334	434	INJURED
3	M	276	311	338	372
4	M	322	334	434	444
5	M	311	334	353	376
6	M	334	344	411	444
7	M	188	276	372	434
8	M	311	334	388	411
9	M	334	354	434	450
10	M	334	350	444	450
11	M	334	344	434	444
12	F	173	185	219	242
13	F	162	219	253	265
14	F	139	242	276	299
15	F	150	196	230	242
16	F	230	253	253	265
17	F	162	196	196	208
18	F	INJURED	265	288	334
19	F	162	162	196	230
20	F	208	242	253	265
21	F	150	208	230	253
22	F	185	219	230	INJURED
23	F	208	219	242	265
24	F	208	288	311	334
25	F	162	185	208	242

APPENDIX C

GROUP A -- BENCH PRESS STRENGTH TEST RESULTS

GROUP A -- BENCH PRESS TEST RESULTS

N	SEX	TEST 1	TEST 2	TEST 3	TEST 4
1	M	190	208	215	220
2	M	110	119	137	146
3	M	119	128	137	137
4	M	155	190	190	208
5	M	155	173	181	181
6	M	164	173	181	181
7	M	119	146	146	164
8	M	155	164	181	190
9	M	181	208	220	230
10	M	173	199	199	215
11	M	128	146	155	155
12	F	71	83	83	95
13	F	71	83	89	101
14	F	53	65	71	77
15	F	53	59	71	71
16	F	59	71	83	83
17	F	53	65	71	77
18	F	83	89	101	110
19	F	71	77	83	95
20	F	65	71	77	83
21	F	77	89	101	119
22	F	65	71	77	77
23	F	53	59	71	71
24	F	59	65	77	83
25	F	59	59	71	77
26	F	53	59	65	65

APPENDIX D

GROUP B -- BENCH PRESS STRENGTH TEST RESULTS

GROUP B -- BENCH PRESS TEST RESULTS

N	SEX	TEST 1	TEST 2	TEST 3	TEST 4
1	M	190	199	208	213
2	M	110	128	137	137
3	M	190	208	215	220
4	M	128	137	146	146
5	M	101	110	119	128
6	M	119	128	137	146
7	M	110	128	146	146
8	M	128	137	137	146
9	M	190	208	213	213
10	M	199	199	199	208
11	M	146	164	164	173
12	F	59	59	71	77
13	F	71	83	83	95
14	F	71	71	83	83
15	F	65	65	77	83
16	F	65	71	77	83
17	F	47	59	59	59
18	F	65	65	77	77
19	F	71	83	83	95
20	F	65	65	71	77
21	F	53	65	77	77
22	F	71	83	89	95
23	F	59	65	83	95
24	F	65	65	71	83
25	F	59	59	65	71

APPENDIX E

SQUAT PRESS SCHEFFE' TEST RESULTS (Sex + Trng. Prog.)

SQUAT PRESS SCHEFFE' TEST RESULTS (Sex + Trng. Prog.)

MEAN 1	MEAN 2	N in GRP. A	N in GRP. B	SSw	F
235.8	273.3	47	47	386.3	85.5472*
235.8	315.2	47	47	386.3	383.5170*
235.8	335.9	47	47	386.3	609.5530*
273.3	315.2	47	47	386.3	106.8000*
273.3	335.9	47	47	386.3	238.3920*
315.2	335.9	47	47	386.3	26.0666*

*F (.05, 3, 129) = 8.04

APPENDIX F

BENCH PRESS SCHEFFE' TEST RESULTS (Sex + Trng. Prog.)

BENCH PRESS SCHEFFE' TEST RESULTS (Sex + Trng. Prog.)

MEAN 1	MEAN 2	N in GRP. A	N in GRP. B	SSW	F
99.8	110.3	51	51	20.6	136.4750*
99.8	118.0	51	51	20.6	410.0300*
99.8	124.3	51	51	20.6	743.0280*
110.3	118.0	51	51	20.6	73.3929*
110.3	124.3	51	51	20.6	242.6210*
118.0	124.3	51	51	20.6	49.1309*

*F (.05, 3, 141) = 8.01

APPENDIX G

SQUAT PRESS SCHEFFE' TEST RESULTS (Males Only)

SQUAT PRESS SCHEFFE' TEST RESULTS (Males Only)

MEAN 1	MEAN 2	N in GRP. A	N in GRP. B	SSw	F
311.0	337.6	20	20	447.7	15.8043*
311.0	408.0	20	20	447.7	210.1630*
311.0	424.9	20	20	447.7	289.7750*
337.6	408.0	20	20	447.7	110.7030*
337.6	424.9	20	20	447.7	170.2320*
408.0	424.9	20	20	447.7	6.3795

*F (.05, 3, 54) = 8.37

APPENDIX H

BENCH PRESS SCHEFFE' TEST RESULTS (Males Only)

BENCH PRESS SCHEFFE' TEST RESULTS (Males Only)

MEAN 1	MEAN 2	N in GRP. A	N in GRP. B	SSw	F
148.2	163.6	22	22	27.3	95.5589*
148.2	171.0	22	22	27.3	209.4590*
148.2	177.4	22	22	27.3	343.5540*
163.6	171.0	22	22	27.3	22.0644*
163.6	177.4	22	22	27.3	76.7339*
171.0	177.4	22	22	27.3	16.5040*

*F (.05, 3, 60) = 8.28

APPENDIX I

SQUAT PRESS SCHEFFE' TEST RESULTS (Females Only)

SQUAT PRESS SCHEFFE' TEST RESULTS (Females Only)

MEAN 1	MEAN 2	N in GRP. A	N in GRP. B	SSw	F
180.1	225.7	27	27	342.1	82.0560*
180.1	246.5	27	27	342.1	173.9870*
180.1	270.0	27	27	342.1	318.9330*
225.7	246.5	27	27	342.1	17.0729*
225.7	270.0	27	27	342.1	77.4440*
246.5	270.0	27	27	342.1	21.7930*

*F (.05, 3, 75) = 8.19

APPENDIX J

BENCH PRESS SCHEFFE' TEST RESULTS (Females Only)

BENCH PRESS SCHEFFE' TEST RESULTS (Females Only)

MEAN 1	MEAN 2	N in GRP. A	N in GRP. B	SSw	F
63.1	69.8	29	29	15.6	41.7247*
63.1	77.8	29	29	15.6	200.8530*
63.1	83.9	29	29	15.6	402.1330*
69.8	77.8	29	29	15.6	59.4872*
69.8	83.9	29	29	15.6	184.7910*
77.8	83.9	29	29	15.6	34.5861*

*F (.05, 3, 81) = 8.16

APPENDIX K

INFORMED CONSENT FORM

INFORMED CONSENT
UNIVERSITY OF WISCONSIN-LA CROSSE
LA CROSSE, WISCONSIN 54601
P.E. 100 Sec. 1 and 2

PROJECT TITLE: A comparison of Two Circuit Strength Training Programs on University Aged Males and Females.

Principle Investigator: Bob Strelka

1. Procedures to be followed:
2. Potential discomforts or risks to be expected by the subject:
3. Potential benefits to the subject:
4. Questions concerning procedures, risks, or benefits:

A. I, _____, being of sound mind and _____
(Name of subject)
years of age, do hereby consent to, authorize and request the named person above (and his co-workers) to undertake and perform on me the proposed investigation (herein called "Procedure").

B. I have read the above document and I have been fully advised of the nature of the Procedure and possible risks and complications involved in it, all of which risks and complications I hereby assume voluntarily.

C. I hereby acknowledge that no representations, warranties, guarantees or assurances of any kind pertaining to the Procedure have been made to me by the University of Wisconsin-La Crosse, the officers, administration, employees, or by anyone acting on behalf of any of them.

D. I understand that I may withdraw from the program at any time. Signed at _____ this _____ day of _____, 1985, in the presence of the witnesses whose signatures appear below opposite my signature.

Witnessed By:

_____ _____
(Subject)