# COMPARISON OF 30 AND 90 SECOND REST

## PERIODS BETWEEN SETS OF A

## RESISTANCE TRAINING

# **PROGRAM**

By

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#### CHAPTER I

A REST REST AND

#### INTRODUCTION

There has been rapid advancement in scientific research relating to muscle strength and endurance. Little doubt remains today as to the importance of muscular strength and endurance in competitive sports and in the demands of everyday physical activities.

Strength training regimens increase both endurance and strength in the muscle. Muscular endurance and muscular strength are closely related; as one improves, there is a tendency for the other to improve also. Although there is not agreement as to the specific number of sets and repetitions that should be used, it is generally accepted that to develop muscular strength, heavier weights should be used with a lower number of repetitions. Conversely, to improve muscular endurance, lighter weights should be used with a higher number of repetitions (Fleck and Kraemer, 1987).

Much of the pioneering information on resistance training was done by DeLorme and Watkins (1948). Their research contradicted initial publications concerning resistance exercise in which 70 to 100 repetitions were advocated for gains in muscle strength. Their experience showed this figure to be too high, and that instead, a total of 20 to 30 repetitions (broken down into three sets) was far more satisfactory. They explained that fewer repetitions with greater resistances yielded larger strength gains, whereas higher repetitions with lesser resistances produced greater endurance gains.

Research by DeLorme and Watkins (1948) demonstrated that performing three sets of 6-10 repetitions, was optimal in resistance exercise.

One concept that has been largely overlooked, though, is the length of rest periods between sets and its influence on strength responses. Because little to no experimental evidence on rest periods could be found, it is apparent that there is a considerable need for information on the effectiveness of rest periods between sets in strength training.

#### Statement of the Problem

The purpose of this study was to investigate the effect of two different between set rest periods, on muscular strength and endurance, and selected body mass indices, among college aged men and women participating in a 12 week resistance training program.

## Hypotheses

The following hypotheses will be tested at the .05 level:

- There will be no significant group, time, or group by time body weight differences for male participants in this study.
- 2. There will be no significant group, time, or group by time body weight differences for female participants in this study.
- 3. There will be no significant group, time, or group by time body fat percentage differences for male participants in this study:
- 4. There will be no significant group, time, or group by time body fat percentage differences for female participants in this study.
- There will be no significant group, time, or group by time Quetelet Body Mass
   Index (BMI) differences for male participants in this study.
- There will be no significant group, time, or group by time Quetelet Body Mass
   Index (BMI) differences for female participants in this study.
- 7. There will be no significant group, time, or group by time leg strength differences for male participants in this study.
- 8. There will be no significant group, time, or group by time leg strength differences for female participants in this study.

- 9. There will be no significant group, time, or group by time upper body strength differences for male participants in this study.
- 10. There will be no significant group, time, or group by time upper body strength differences for female participants in this study.
- 11. There will be no significant group, time, or group by time upper body endurance differences for male participants in this study.
- 12. There will be no significant group, time, or group by time upper body endurance differences for female participants in this study.

### Limitations

The following limitations apply:

- Subjects were not chosen randomly.
- 2. There were only 30 females and 25 males in this study.
- 3. Computerized equipment was not available to test strength and endurance.

#### **Delimitations**

The following delimitations apply:

- No attempt was made to control the subjects' diet.
- Other than verbal instruction, there was no attempt to control the subjects' extracurricular activities involving exercise.
- Only two (30 and 90 second) rest periods between sets were examined in this study.
- Strengths were measured using 1 RM maximum testing.
- Other than verbal instructions to abstain, subjects were not tested for drugs or ergogenic aids.

## Assumptions

The following assumptions were made:

- Individuals did not participate in a training program that would affect the outcome of this study.
- Subjects were not taking drugs or other ergogenic aids that would have affected the outcome of this study.
- 3. All subjects made maximal effort in response to the maximal strength tests.

#### Definitions

Antagonistic- muscles that work in contrast to one another.

<u>Anthropometry</u> anthropometric variables can be used to predict total body fat or fatfree mass using regression equations (statistical equations used to predict performance on one variable from another).

Atrophy- a decrease in the size of muscles as a result of disease or non-usage.

Body Fat Percentage- (Body Composition) the proportion of body fat to lean body tissue.

Body Mass Index (BMI)- a ratio of body weight to height used as a means to determine the extent of overweight.

Body Morphology- the equality of body somatotype between all three components.

<u>Somatotype</u>- the body type or physical classification of the body. The terms endomorph, mesomorph, and ectomorph are used to describe a person in terms of his or her somatotype.

Endomorph- the first component of somatotyping, characterized by roundness and softness of the body.

Mesomorph- the second component of somatotyping, characterized by a square body with hard, rugged, and prominent masculation.

Ectomorph- the third component of somatotyping, characterized by linearity, fragility, and delicacy of body.

<u>CYBEX Weight Machines</u> a brand of variable resistance weight machines used in this study for developing strength.

<u>Delimitation</u>- refers to the scope of the study. Delimitations spell out the population studied and include those things the researcher can control.

Diameter- a measurement across an object.

Electromyogram (EMG)- a recording of the electrical activity of a muscle.

Ergogenic Aid- the use of a nutritional, physical, mechanical, psychologic, or pharmacologic procedure or aid to improve physical work capacity or athletic performance.

<u>Fatigue (Volitional)</u>- fatigue which ensues from voluntary contractions/repetitions. In volitional fatigue, a 10 RM would be using the maximal resistance for a specific muscle/muscle group, whereby 10 repetitions could be performed.

<u>Fatigue (Local)</u>- fatigue which follows voluntary contractions/repetitions. In local fatigue, exhaustion would hinder an 11th repetition.

Frequency- the number of times an exercise is done in a week's period.

Girth- a measurement around an object.

<u>Hypertrophy</u>- an increase in the size of muscles as the result of strength training.

Intensity- the amount of weight or resistance lifted.

<u>Isometric-</u> a contraction of a muscle to produce tension without a change in the length of the muscle.

<u>Limitation</u>- refers to weaknesses of the study. Limitations are those things the researcher could not control, but which may have influenced the results of the study.

Mole- a chemical weight equivalent represented by the quantity of a substance necessary to equal its molecular weight

Millimole- a unit of measure which represents a chemical weight equivalent equal to 0.001 moles. Referred to as mm.

Motor Unit- a single motor nerve that controls a group of muscle fibers.

<u>Muscular Endurance</u> the ability to perform repetitive muscular contractions against resistance for an extended period of time.

Muscular Overload- working a muscle against a load greater than normal to obtain an improvement.

Muscular Strength- the ability of a muscle to generate force against resistance.

Musculature- the detailed external appearance of a muscle, or of the body as a mass of muscles.

Neural Adaptation— as defined by Sale (1988), changes within the nervous system that allow force to be developed more rapidly and peak force to be maintained longer.

Neural Mechanism- where the motor neuron innervates the muscle fiber.

<u>Peak Force</u> the highest amount of power or compulsion produced.

Ponderal Index- a table used to determine the third component of somatotype. The Ponderal index is equal to the subject's height, divided by the cubed square root of their weight (Ht./3\sqrt{Wt.}).

Prime Mover- the primary muscle being worked.

Rate of Force- the frequency of the force produced.

Repetitions- the number of times a specific movement is repeated.

Repetition Maximum (RM)- the number of repetitions which can be accomplished using a particular resistance, prior to volitional fatigue precluding additional repetitions.

One repetition maximum— (1 RM) a one repetition maximum lift. The maximum amount of weight successfully lifted at one time through the full range of motion before fatigue precludes additional repetition(s).

Five repetition maximum- (5 RM) would involve use of a resistance which would permit five repetitions prior to local fatigue precluding a sixth repetition.

Resistance Training- a program using resistance exercises to increase strength,

Resistance Training Components- number of repetitions, sets, exercises per sessions, workouts per week, and the rest intervals which separate each.

Rest Interval- amount of time allotted for rest between sets.

Set- a particular number of repetitions.

endurance, power, skill, and flexibility.

<u>Skinfold-</u> a fold of skin measured with calipers at various body sites. By measuring a skinfold thickness, the total percentage of body fat can be calculated.

<u>Somatotype Categories</u>— the following are somatotype categories along with how they are determined. In the following categories the components are referred to in order of first, second, or third. The first component is endomorphy; the second component is mesomorphy; the third component is ectomorphy.

Balanced endomorphy- the first component is dominant and the second and third components are equal (or do not differ by more than one-half unit).

Mesomorphic endomorph- endomorphy is dominant and the second component is greater than the third.

Mesomorph-endomorph- the first and second components are equal (or do not differ by more than one-half unit) and the third component is smaller.

Endomorphic mesomorph- the second component is dominant and the first component is greater than the third component.

Balanced mesomorph- the second component is dominant and the first and third components are less and equal (or do not differ by more than one-half unit).

Ectomorphic mesomorph- the second component is dominant and the third component is greater than the first component.

Mesomorph-ectomorph- the second and third components are equal (or do not differ by more than one-half unit) and the first component is lower.

Mesomorphic-ectomorph- the third component is dominant and the second component is greater than the first component.

Balanced ectomorph- the third component is dominant and the first and second components are equal and lower (or do not differ by more than one-half unit).

Endomorphic ectomorph- the third component is dominant and the first component is greater than the second component.

Endomorph-ectomorph- the first and third components are equal (or do not differ by more than one-half unit) and the second component is lower.

Ectomorphic endomorph- the first component is dominant and the third component is greater than the second component.

<u>Central</u>- no component differs by more than one unit from the other two, and consists of ratings of 3 and 4.

Synergistic- muscles that work in concord with one another.

Two-Way Analysis of Variance (ANOVA)— a statistical method for examining data. It is used to test several hypotheses about differences between means in the factorial design.

#### CHAPTER II

### LITERATURE REVIEW

## History of Resistance Training

The history of resistance training can be traced to the Olympic champion, Milo of Crotona, who lived in Greece during the sixth century BC. Milo is said to have lifted a baby bull to his shoulders, every day, to improve his strength. As the bull grew in size with time, so did Milo's strength (Brooks, Fahey, and White, 1996). The first mention of this increasing resistance as muscular overload first appeared in the scientific literature in 1919 (Lange, 1919). This landmark scientific study which established the optimal nature of this overload for muscular strength and endurance was conducted by DeLorme and Watkins (1948).

## Specificity of Resistance Training

In the decades following DeLorme and Watkins (1948) pioneering work, resistance training has become increasingly specialized and varied to meet a variety of goals and needs including: strength and power, endurance, and hypertrophy (Fleck and Kraemer, 1997). For muscular strength and power, resistances should be sufficient to result in no more than five maximal repetitions (5 RM) per set, 3-10 sets, and rest periods exceeding two minutes between sets. For muscular endurance, the recommendations are 12-25 RM per set, 2-3 sets, and rest periods of two to three minutes between sets if performing >20 RM. If performing <20 RM, the recommended rest period is 30-60 seconds. For muscular hypertrophy, the program would consist of 6-12 RM per set, 2-3 sets, and 30-90 second rest period between sets.

The specific number of exercises to perform is subject to considerable debate and partly dependent upon specific goals and needs. For example, a body builder may

incorporate a large number of exercises into his/her resistance training program to attain muscular hypertrophy and definition in a large percentage of total body musculature, while strength and power athletes may focus more specifically on the limited musculature beneficial to their competitive event(s) (Fleck and Kraemer, 1997). The American College of Sports Medicine (1990) recommends 8 to 10 specific exercises, involving the major muscle groups, for the attainment and maintenance of muscular strength and endurance in the general population. Generally speaking, the rest period between workouts should be at least one day, such that three workouts per week will occur (Fleck and Kraemer, 1997); however, studies demonstrate that elite level, competitive athletes may be capable of and need more extensive and frequent training to realize improvements in size and strength (Kraemer, Noble, Clark, and Culver, 1987) and performance (Hoffman, Kraemer, Fry, Deschenes, and Kemp, 1990).

## Variations in Resistance Training Components

While variations in resistance training components relative to the attainment of specific goals has been previously discussed, many of the components are specified in the form of a "range" while others are not specified. Accordingly, it is the purpose of this section to examine studies which have further explored variations within specified ranges. Graves, Pollock, Jones, Colvin, and Leggett (1989) demonstrated maximal benefits will accrue from resistance training, when a full range of motion is involved with each repetition.

In a general population, increased frequency of training and additional sets elicit larger strength gains; however, the magnitude of difference is small (Fleck and Kraemer, 1997). In a study completed by Braith, Graves, Pollock, Leggett, Carpenter, and Colvin (1989), subjects exercising one or two days a week experienced almost the same magnitude of strength gains experienced by subjects exercising three days a week, with

no difference between one and two day per week subjects during an 18 week, resistance training program.

#### Rest Between Contractions

According to a study by Rooney, Herbert, and Balnave (1994), subjects who trained by repeatedly lifting the training weight without resting experienced substantially greater increases in strength than subjects who trained with rests between lifts. It is evident that subjects in the no-rest group experienced greater levels of fatigue than subjects in the rest group. The data of this investigation assert that the strength increases associated with short-term strength training programs will be greater if subjects do not rest between contractions. This suggests that processes associated with fatigue add to the stimulus by which training influences increase muscular strength.

In a MEDLINE search spanning the past 20 years (using the key words "rest periods" and "rest periods between sets" in resistance training), only one study was found which investigated the manipulation of rest period between sets. In this study, Pincivero, Lephart, and Karunakara (1997), had 15 healthy, college-age individuals exercise one leg, three days a week, using isokinetic knee extensions and flexions, performed at 90 degrees per second. One group (n=8) rested 40 seconds between sets, while the remaining group (n=7) rested 140 seconds between sets. Post testing, at the end of four weeks, revealed the 140 second rest group exhibited superior performance for isokinetic hamstring total work and average power at 180 degrees per second.

#### Summary

Progressive, resistance exercise is a well established method of increasing muscular strength and endurance (DeLorme and Watkins, 1948; American College of Sports Medicine, 1990; Fleck and Kraemer, 1997). The individual components of a resistance training program can be varied to meet a wide variety of individual goals,

objectives, and needs (Fleck and Kraemer). Within the general population, the attainment of desired results, such as strength and endurance, can occur within a wide application range of resistance training components, with only minimal resultant differences at the recommended range extremes (Braith et al., 1989). Within a population of elite, competitive athletes, the attainment of optimal results, such as strength, size, and performance, will likely require a more frequent and extensive application of resistance training components than would be necessary for the general population (Kraemer et al., 1987; Hoffman et al., 1990).

Finally, almost no research could be found addressing the possible resultant differences which could occur from manipulating the rest period between sets, within the prescribed range, for a particular resistance training protocol. Accordingly, this manuscript will examine the range extremes of between set rest periods, prescribed for a typical, resistance training program as taught in college classes.

#### CHAPTER III

## METHODS AND PROCEDURES

#### Methods

## Subjects

A total of 30 women and 25 men were recruited to participate in this study. The mean group ages and physical characteristics of these subjects are presented in Tables 1 and 2. All subjects (control and experimental) read and signed a PAR-Q form (Appendix A). Subjects were between the ages of 18 and 26 years at the time of testing, and all subjects were apparently healthy as reflected by the PAR-Q form. When orally polled, none of the subjects were engaged in a regular or organized weight training program.

## Control Group

A sum of seven men and seven women volunteered to participate in this study as control subjects. All 14 individuals were students attending St. Gregory's College in Shawnee, Oklahoma.

## Experimental Group

The experimental subjects were enrolled in weight training classes at St.

Gregory's College and East Central University in Ada, Oklahoma. Both classes met for a period of 16 weeks with an attendance of three, 45 minute sessions per week.

Experimental subjects were divided into either a 30 second or a 90 second rest group by insuring equal numbers of each somatotype per group.

Body somatotyping. Body somatotyping was performed to insure equal placement of subjects within experimental groups. This was done by matching subject groups according to their strength and somatotype. This was important as differences in muscle fiber composition and cross sectional area have been shown to effect results of resistance training (Dons, Bollerup, Bonde-Petersen, & Hancke, 1979). The terms endomorph, mesomorph, and ectomorph were used to describe a person in terms of his or her somatotype. Sheldon (1954) describes each classification:

## Endomorphy

This component is characterized by roundness and softness of the body.

Features of this type are predominance of the abdomen over the thorax, high square shoulders, and a short neck. There is usually a smoothness of contours throughout, with no muscle relief.

## Mesomorphy

This component is characterized by a square body with hard, rugged, and prominent musculation. The bones are large and covered with thick muscle. The legs, trunk, and arms are usually massive in bone and heavily muscled throughout.

Outstanding characteristics of this type are forearm thickness and heavy wrists, hands, and fingers. The thorax is large and the waist is relatively slender. The shoulders are broad; the trunk is usually upright, and the trapezius and deltoid muscles are quite massive. The skin appears coarse and acquires deep tan readily, retaining it for a long time. Many athletes have a large degree of this component.

### **Ectomorphy**

The last component includes linearity, fragility, and delicacy of body.

This is the leanness component. The bones are small and the muscles thin. Shoulder droop is seen consistently in the ectomorph. The limbs are relatively long and the trunk short; however, this does not necessarily mean the individual is tall. The abdomen and

the lumbar curve are flat. The shoulders are mostly narrow and lacking in muscle relief.

There is no bulging of muscle at any point on the physique.

Sheldon (1954) stated that a pure type does not exist, but that each person is made up in part of all three components. As mentioned before, the subjects were distributed by their somatotype. The distribution insured, as nearly as possible, an equal distribution of numbers, body somatotype, and starting strength, by group and gender. The female, 30 second rest group included the following somatotypes: six classified as mesomorphic endomorph, two as balanced endomorphy, two as endomorph-ectomorph, one as ectomorphic endomorph, and one as ectomorph mesomorph. The female, 90 second rest group included these somatotypes: six classified as mesomorph-endomorph, three as balanced endomorphy, one as mesomorphic endomorph, and one as endomorph-ectomorph.

Among male subjects, the somatotypes in the 30 second rest group included the following: five as endomorphic mesomorph, two as balanced mesomorph, one as mesomorph-endomorph, and one as central. The male, 90 second rest group incorporated these somatotypes: four endomorphic mesomorph males, two balanced mesomorph males, one mesomorphic endomorph male, one mesomorph-endomorph male, and one balanced ectomorph male.

Additionally, no attempt was made to distribute the control subjects by their somatotype. Subjects in the control group were volunteer participants who were an agreeable sample of the student body at St. Gregory's College. Somatotyping was not done on these individuals.

## Attrition of Subjects

The subjects were asked to sign a contract at the beginning of the semester which stated they would attend each class for the duration of the study. Additionally, if a

subject was absent, he or she was responsible to make up the missed class within the week, in order to remain eligible. Participants who were absent on a regular basis and/or did not make up the missed classes were dropped from the study.

### Procedures

## Training

Pre-conditioning. Based on the format used in a study by O'Shea and Wegner (1981), the subjects (both control and experimental) in this study began with a two week introduction and conditioning program to familiarize them with the testing and training procedures to be followed during the experimental period. Instruction was also given on correct lifting techniques and how to maximally apply force prior to being tested.

During the two week pretest conditioning period, the subjects became familiar with the equipment and exercises to be used during the experimental period. Correct lifting technique was stressed, and no one was permitted to attempt a one repetition maximum (1 RM) lift at any time during this period. Repetitions were set at a minimum of eight and a maximum of 12 for three sets.

The purpose for the two week training session was to verify that any differences between initial and final values were more likely to reflect true gains in strength and less likely to be influenced by practice or learning effects. Strength and endurance were assessed on all subjects at the completion of the second week of the program and again at the end of the program.

Resistance training. For the 10 weeks following the pre-conditioning period, the experimental subjects participated in a strength training program three times a week under supervision from the class instructors. The training format for the two experimental groups was identical. After five minutes of general warm-up exercises, each subject completed three sets of the following exercises using CYBEX machines: leg extension, leg curl, horizontal leg press, Smith machine (for bench press), bicep curl, tricep extension, lat pull, and rear row adduction (Figures 1, 2 3, 4, 5, 6, 7, 8). All three sets were performed with a starting weight which could be lifted only 10-12 repetitions (Gettman, Ayres, Pollock, & Jackson, 1978, Rooney et al., 1994, Wilmore, 1974). When the subject had increased his or her strength to the point where the same weight could be lifted more than 12 repetitions for all sets, additional weight was added, which reduced the number of repetitions back to the initial level. Generally, the weight added was five pounds for upper body and 10 pounds for lower body. Weight was added in this manner throughout the 10 week program at the point when the subjects were able to perform 12 repetitions in all three sets. Each subject was encouraged to perform to his or her maximum effort each set. Subjects kept records of each training day throughout the study period, including each exercise machine used, amount of weight lifted, number of sets performed, and number of repetitions completed. Subjects in the control group did not train. These individuals did not perform any upper body or lower body strength training exercises for the 10 week period of the study. They did, however, undergo the same testing procedures at the completion of the second week of the program and again at the end as the experimental groups. The training period of the study was performed from February of 1996 to May of 1996.

### Collection of Data

Body weight. To determine body weight, subjects were weighed on a Health-O-Meter, eye level physician's balance beam scale. All subjects were weighed wearing shorts, t-shirts, and socks. Shoes were removed prior to weighing. An allowance of 2.5 pounds per person was allowed for clothing.

Body fat percentage. Body composition was assessed at the beginning and at the end of the study using a Harpenden skinfold caliper. The seven-site method of Jackson and Pollock (1985) was used to assess body fat percentage for both men and women.

Body somatotyping. A series of anthropometric measurements were also taken at the beginning and at the conclusion of the study using the format suggested by Fox and Mathews (1981). All measurements were taken by the same person. The measurements included skinfold thicknesses from the triceps, subscapular, supraliac, and calf. Diameters were taken at the knee and elbow. Circumferences were measured at the chest, abdomen, hips, thigh, calf, biceps extended, biceps flexed, and forearm. A minimum of two measurements were taken at each site. For circumferences and diameters, a third measurement was taken whenever the first two values differed by more than one percent. For skinfold thickness, a third measurement was taken whenever the first two values differed by more than 0.5 mm. Diameters were assessed with an anthropometer and girths with a calibrated Gulick cloth tape.

Measurements were collected with the subjects in a standing position and wearing athletic clothing. Clothing was moved/removed to obtain skin measures where practical. Once measurements had been made, experimental subjects were divided into either a 30 second or a 90 second rest group according to their somatotype. All pretest measurements were taken before the subjects began any training.

Body anthropometry. Most of Sheldon's data dealt primarily with males. Due to this, Heath and Carter (1967) contributed to the field of somatotyping for both males and females by designing a method to calculate each component:

Endomorphic Component

To obtain this component, the somatotype rating form is used (Appendix B). See Appendix C for instructions on how to determine this component.

Mesomorphic Component

The somatotype rating form is again used in this type. See Appendix D for steps to determine this component.

Ectomorphic Component

This last component is obtained by computing the Ponderal index, which is explained in Appendixes E and F.

Quetlet body mass index. Each person's body mass index was assessed at the beginning and at the end of the study. Quetlet's method was used to assess body mass indices for both men and women (Flegal, 1990).

Strength and endurance measures. Following the two week training period, strength was assessed by a 1 RM bench press for upper body and a 1 RM leg press for lower body. As suggested by O'Shea and Wegner (1981), the training loads used by each subject during the preconditioning period were analyzed to minimize the trial-and-error of determining the 1 RM. This analysis consisted of predicting a target 1 RM that was 25% greater than the weight each subject could lift for 8 to 12 repetitions. Based on this analysis, a target 1 RM was projected. Using this target 1 RM as a guide, the subjects warmed up by doing eight repetitions with 60% of their target lift, progressed to 75% for three repetitions, 90% for one repetition, and then attempted the target 1 RM.

When the subjects were successful in lifting the target 1 RM, the load was increased by five pounds in the bench press and 10 to 15 pounds in the leg press, and another attempt was made. Each subject was given two sessions in which to establish his or her max, with 1.5 minutes of rest between each attempt

Endurance was evaluated on a bench press by using a percentage of the subject's body weight. For upper body assessment, the method used to test for relative muscular endurance (women lifted 40% of their body weight and men lifted 60%) was one which has been previously employed in the weight training classes at both institutions (St. Gregoy's College and East Central University). This method was found to result in the ability of subjects to generally perform 15-25 repetitions. The subjects performed the maximum number of repetitions at one second for each concentric and eccentric phase of a repetition (two seconds per repetition) until cadence could not be maintained. An attempt was made to consider the subjects' physiological and psychological states during testing; if the subjects were tired or not feeling up to full strength, their testing was delayed until the following workout period. Because it provided a more accurate assessment, this procedure was followed during all testing.

## Analysis of Data

All experimental variables were analyzed for group, time, and group by time interaction using a two-way analysis of variance (ANOVA) with repeated measures utilizing .05 as the level of significance. The reason for using the two-way ANOVA was to compare the mean scores from the groups in a factorial design in order to decide whether the differences between the means were due to chance or to the main effect for the first variable, the second factor, or a combination of certain levels of one variable paired with certain levels of the other variables. Significant differences were further

delineated using the Newman-Keuls post-hoc test, again utilizing .05 as the level of significance (Bartz, 1976).

### CHAPTER IV

#### RESULTS & DISCUSSION

## Subjects

A total of 55 male and female subjects were tested, incorporating both experimental and control groups. The subjects included 30 women and 25 men. All subjects performed the testing on a voluntary basis. The mean age for the male subjects was 20.8 years. The mean age for the female subjects was 19.1. There were nine subjects in the male 30 second rest group, nine subjects in the male 90 second rest group, and seven subjects in the male control group. There were 12 subjects in the female 30 second rest group, 11 subjects in the female 90 second rest group, and seven subjects in the female control group.

The experimental subjects were distributed by somatotype. The distribution insured, as nearly as possible, an equal distribution of numbers, body somatotype, and starting strength, by group and gender. Additionally, subjects were equally distributed within experimental groups by somatotype and beginning strength measures (1 RM). The female experimental groups included the following somatotypes: the 30 second rest group had six mesomorphic endomorph females, two balanced endomorphy females, two endomorph-ectomorph females, one ectomorphic endomorph female, and one ectomorph females, three balanced endomorphy females, one mesomorphic endomorph female, and one endomorph-ectomorph female. The male experimental groups had the following somatotypes: the 30 second rest group included five endomorphic mesomorph males, two balanced mesomorph males, one mesomorph-endomorph males, and one central male; the 90 second rest group incorporated four endomorphic mesomorph males, two

balanced mesomorph males, one mesomorphic endomorph male, one mesomorphendomorph male, and one balanced ectomorph male.

## Analysis of Data and Results

Results were analyzed using a 2 x 2 ANOVA, with repeated measures.

Significant differences were further delineated using the Newman-Keuls post-hoc test (Bartz, 1976). The level of significance was .05.

## Descriptive Statistics

Descriptive statistic results for male groups are contained in Table 1. Descriptive statistic results for female groups are contained in Table 2.

## Inferential Statistics

Inferential statistic results for both male and female groups are contained in Tables 3-14. Results are presented below.

Body weight. There were no significant differences in body weight in males between any of the groups or either of the times tested (Table 3). Furthermore, there were no significant differences in body weight in females among any of the groups or either of the times tested (Table 4).

Overall, there were no significant differences observed in either the males or females based on group, time, or group by time interaction. This suggests that a 12 week strength training program employing 30 or 90 second rest periods between repetitions will not effect body weight of the subject possessing average body weight.

Percent body fat. The male experimental groups were both significantly different than the control group from pre to post test, but between the experimental groups, there was no difference. The time difference was that percent body fat for males was less after the training period than before (Table 5). Thus, both experimental groups achieved the same benefit.

There were no significant differences for percent body fat for females based on any of the groups. However, there were differences between pre and post test and between groups by time interactions. For the time effect, the ending percent body fat for females was less than it was at the beginning for the experimental groups (Table 6). In the group by time interaction, both experimental groups experienced greater losses of percent body fat than the control group. However, no significant difference existed between experimental groups (Table 6). Additionally, there was no significant difference in body composition in the control group from pre to post test.

These findings suggest that losses in body fat percentage will occur in both males and females during a 12 week strength training regimen, whether the subjects rest 30 or 90 seconds between repetitions. Additionally, the female experimental groups lost a greater percentage of body fat over the training period than did the control group.

Body mass index. There were no significant differences in body mass indices in males between any of the groups or either of the times tested (Table 7). Additionally, no significant differences were found in body mass indices in females between any of the groups or between any of the groups from pre to post test. However, there were differences found between pre test and post test. The time effect demonstrated that the ending BMI in females was less after the training period than before for the experimental groups (Table 8). No significant intergroup differences were found.

This data shows that a 12 week strength training program will not impact BMI in males. It contrast, it also shows that a strength program of this duration has positive effect on the BMI in female subjects.

Leg strength. There were significant differences in 1 RM leg press results for men between all groups, from pre to post test, and between groups by time interactions. In the group effect, both experimental groups had greater leg strength than the control group, with no significant difference between experimental groups. The differences in time were that the ending 1 RM leg press scores were greater than the beginning scores for the male experimental groups (Table 9). For the group by time interaction, both experimental groups improved significantly following training, with the 30 second rest group improving more than the 90 second group. There were no differences in the beginning and ending 1 RM leg press scores for the control group (Table 9).

Significant differences were found in the 1 RM leg press results for women between all groups, from pre to post test, and between groups by time interactions. For the group effect, both experimental groups had greater leg strength than did the control group, but with no significant differences between experimental groups. The differences in time were that the ending 1 RM leg press scores were greater than the beginning scores for the female experimental groups (Table 10). For the group by time interaction, both experimental groups improved significantly following training, with the 30 second rest group improving more than the 90 second group. There were no indicative differences in the beginning and ending 1 RM leg press scores for the control group (Table 10).

These results from both male and female experimental groups indicated improvements in strength over a 12 week period. Additionally, the experimental groups

that had the short rest period improved more than the groups that had the long rest period.

Upper body strength. No significant differences were found in males in the 1 RM bench press results among any of the groups. However, there were differences from pre to post test and between groups by time interactions. The differences in time were that the ending 1 RM bench press results were greater than the beginning scores for the male experimental groups (Table 11). For the group by time interaction, both experimental groups improved significantly following training, with the 30 second rest group improving more than the 90 second group. There were no significant differences in the beginning and ending 1 RM bench press values for the control group (Table 11).

There were significant differences in 1 RM bench press results for women between all groups, from pre to post test, and between groups by time interactions. For the group effect, both experimental groups displayed greater upper body strength than did the control group, but with no differences between the experimental groups. The differences in time were that the 1 RM bench press scores were greater at the end of the training period than at the beginning for experimental groups (Table 12). For the group by time interaction, both experimental groups improved significantly following training, with the 30 second rest group improving more than the 90 second group. There were no significant differences detected in the beginning and ending 1 RM bench press scores for the control group (Table 12).

Again, these results indicate that the male and female experimental groups improved in strength over a 12 week strength training program. Once more, the experimental groups that had the 30 second rest periods improved more than the groups that had the 90 second rest periods.

Upper body endurance. There were no indicative differences in bench press endurance results for men between any of the groups. However, there were differences from pre to post test and between groups by time interactions. The differences in time were that the ending bench press endurance results were greater after the training period than before for the male experimental groups (Table 13). For the group by time interaction, both experimental groups improved significantly following training, with the 90 second rest group improving more than the 30 second rest group. There were no significant differences in the beginning and ending bench press endurance values for the control group (Table 13).

No significant differences were found in bench press endurance results for women between any of the groups. However, differences were found between pre and post test and between groups by time interactions. The differences in time were that the bench press endurance repetitions were greater at the end of the training period than at the beginning for the experimental groups (Table 14). For the group by time interaction, both experimental groups improved significantly following training, with no significant difference between experimental groups. There was no notable difference between beginning and ending bench press endurance repetitions for the control group (Table 14).

These results indicate that both the male and female experimental groups improved in strength over a 12 week strength training program. The male experimental group that had the 90 second rest period displayed significantly greater endurance gains than the 30 second rest group; however, although both female experimental groups improved significantly following training, there was not a significant difference between them.

### CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### Introduction

The statistical analyses of the data used in this study indicated various differences between the 30 second and 90 second rest groups. These differences provide a number of significant observations about the effects that two different rest periods have between sets, on muscular strength and endurance, and selected body mass indices, among college aged men and women participating in a 12 week resistance training program. A summary of these observations are as follows:

## **Body Weight**

As stated before, no significant differences were observed in either males or females in body weight. These results indicate that a 12 week strength training program utilizing 30 or 90 second rest periods between repetitions will not bring about changes in weight of the subject possessing average body weight.

### Percent Body Fat

Percent body fat observations illustrated a loss for both males and females from pre to post test results. Moreover, improvements were noticed in the female experimental groups in that they lost a greater percentage of body fat over the 12 week training period than the control group experienced. These results indicate that losses in body fat percentage will occur in normal weight females during strength training, whether the subjects rest 30 or 90 seconds between repetitions.

### BMI

The results demonstrated that there were no BMI differences in male groups in this study. This indicates that a 12 week strength training program, applying either a 30 or 90 second rest period between repetitions, will not impact BMI in males. Yet, the loss of BMI in women in this study, demonstrates that a 12 week period of strength training has positive effect on the female subjects, whether they utilize a 30 or a 90 second rest period between repetitions.

## Strength and Endurance

Improvements in leg strength were shown in both male and female experimental groups. Furthermore, the experimental groups that had the short rest period improved more than the groups that had the long rest period. This data conflicts with literature by Fleck and Kraemer (1987) which states that relatively long rest periods and heavy resistances result in strength gains; whereas short rest periods and light resistances result in endurance gains. An explanation for the strength gains in the groups with the short rest period could be that additional motor units were activated due to fatigue setting in.

Results in upper body strength also indicate that male and female experimental groups improved in strength. And again, the experimental groups that had the 30 second rest periods improved more than the groups that had the 90 second rest periods. Clearly, the findings of this study indicate that the short rest period was associated with greater increase in strength pertaining in upper and lower body strength measures for both genders. These inferences contradict allegations cited from Fleck and Kraemer (1987). They state that if the goal of the weight training program is to increase the ability to exhibit maximal strength, long rest periods (several minutes) and heavy resistances should be used.

The upper body endurance results indicate the long rest period was associated with greater endurance results than the short rest period did, with respect to males. The male 90 second group displayed greater endurance gains; whereas the female 90 second group did not. Additionally, the findings of this study indicate that the short rest period resulted in a greater increase in strength. The data also suggest that the long rest period resulted in a greater increase in endurance. Again, these conclusions contradict allegations cited from Fleck and Kraemer (1987). They state that if the goal of the weight training program is to increase the ability to perform high-intensity exercise, rest periods between sets should be less than one minute. Fleck and Kraemer further state that if long-term endurance (aerobic power) is the goal, then short rest periods and relatively light resistances are suggested.

The findings of the present study support findings by the American College of Sports Medicine (1990), noting that resistance training programs will produce gains in both strength and endurance. Furthermore, the American College of Sports Medicine states that the best way to develop muscular strength is by using heavy weights (that require maximum or nearly maximum tension development) with few repetitions; the best way to develop muscular endurance is through using lighter weights with a greater number of repetitions. Fleck and Kraemer (1997) agree with this position, stating that increased frequency of training and additional sets draw out larger strength gains.

Pincivero et al. (1997) investigated rest periods between sets (40 and 160 second rest intervals) and demonstrated significant gains in isokinetic hamstring total work and average power at 180 degrees per second. Comparing these results with the present study, both showed strength gains from pre to post test. Additionally, the present study indicated that greater gains in endurance were experienced in the group with the long rest period (90 seconds); whereas the group with the short rest period (30 seconds) experienced greater gains in strength. This challenges the study by Pincivero et al. which

suggests greater strength gains occurred with longer rest period between sets (160 seconds).

The findings in a study by Rooney et al. (1994), suggested that strength increases associated with fatigue are greater if the subjects do not rest between contractions. An assumption underlying this suggestion is that subjects in the no-rest group experienced greater levels of fatigue than subjects in the rest group (30 seconds between lifts). Rooney et al. theorize that high-intensity fatiguing protocols bring about greater activation of motor units than high-intensity non-fatiguing protocols, and that the degree of activation of motor units determines the magnitude of the strength training response. A study investigating fatigue during submaximal isometric contractions stated that as muscles fatigue, they experience a progressively greater activation (Maton, 1981). Based on the study by Maton, Rooney et al. (1994) speculated that fatiguing highintensity contractions provide a better way of activating high-threshold motor units than non-fatiguing high-intensity muscle contractions. Alternatively, fatiguing contractions may instigate a greater training response because they provide a better context in which to learn to more appropriately activate synergistic and antagonistic muscles. Yet another explanation noted was that fatigue-related events trigger adaptations of muscle (Rooney et al.).

Research by Hakkinen and Komi (1986) supports this assumption in stating that most strength training studies typically involve training programs that last 8-20 weeks. In these studies, the early increases in voluntary strength are associated mainly with neural adaptation such as improved coordination or learning and increased activation of prime mover muscles.

Supplementary rational for neural adaptation as a result of strength training is reported by Sale (1988). He reports that it is possible that strength training causes changes within the nervous system that allow a trainee to more fully activate prime

movers in specific movements and to better coordinate the activation of all relevant muscles, thereby effecting a greater net force in the intended direction of movement (Sale). Changes within the nervous system may also allow force to be developed more rapidly and peak force to be maintained longer.

The previously discussed studies may explain why the subjects in the 30 second rest group experienced larger strength gains than the subjects in the 90 second rest group. As a result of fatigue, the 30 second rest group possibly activated additional motor units to achieve greater strength gains than the subjects in the 90 second rest group. The short rest period between sets may exhaust the muscle, causing additional motor units to be activated as the muscle fatigues. Furthermore, it is possible that strength training causes changes within the nervous system, and the effect of those changes generate a greater net force in the intended direction of movement. As reported by Sale (1988), these changes within the nervous system may also allow force to be developed more rapidly and peak force to be maintained longer. This too could explain strength and endurance gains in the experimental groups. Yet, another justification for strength increases could be that the small rest period may not allow the previously used muscle fibers and cells to fully recover. Thus, the body is forced to recruit additional muscle fibers and cells which then could result in more strength gains.

In summary, the findings of this study indicate that in a 12 week resistance training program, subjects had greater strength gains when they were restricted to a 30 second rest period between sets. This study also indicated that male subjects had greater endurance gains when they were restricted to a 90 second rest period between sets. The findings of this study along with the literature cited suggest that the processes associated with fatigue may contribute to strength gains through additional motor unit activation, neural adaptation of the muscle, and/or possibly the recruitment of additional muscle fibers and cells. However, a long rest period between sets appears to hinder fatigue,

allowing the muscle to partially recuperate before being worked again, which results in endurance gains.

### Conclusions

The purpose of this study was to investigate the effect of two different resting periods, between sets, on muscular strength and endurance, and selected body mass indices, among college aged men and women participating in a 12 week resistance training program. The results of the two-way ANOVA with repeated measures utilizing .05 as the level of significance allow the following findings to be stated:

- The first hypothesis which stated that there would be no significant group, time, or group by time body weight differences for male participants was accepted.
- The second hypothesis which stated that there would be no significant group,
   time, or group by time body weight differences for female participants was accepted.
- 3. The third hypothesis which stated that there would be no significant group, time, or group by time body fat percentage differences for male participants was partly accepted and partly rejected. The portions dealing with group and group by time were accepted, while the portion dealing with time was rejected.
- 4. The fourth hypothesis which stated that there would be no significant group, time, or group by time body fat percentage differences for female participants was partly accepted and partly rejected. The portion dealing with group was accepted, while the portions dealing with time and group by time was rejected.
- The fifth hypothesis which stated that there would be no significant group, time, or group by time Quetelet Body Mass Index (BMI) differences for male participants was accepted.

- 6. The sixth hypothesis which stated that there would be no significant group, time, or group by time Quetelet Body Mass Index (BMI) differences for female participants was partly accepted and partly rejected. The portions dealing with group and group by time were accepted, while the portion dealing with time was rejected.
- 7. The seventh hypothesis which stated that there would be no significant group, time, or group by time leg strength differences for male participants was rejected.
- 8. The eighth hypothesis which stated that there would be no significant group, time, or group by time leg strength differences for female participants was rejected.
- 9. The ninth hypothesis which stated that there would be no significant group, time, or group by time upper body strength differences for male participants was partly accepted and partly rejected. The portion dealing with group was accepted, while the portions dealing time and group by time was rejected.
- 10. The tenth hypothesis which stated that there would be no significant group, time, or group by time upper body strength differences for female participants was rejected.
- The eleventh hypothesis which stated that there would be no significant group, time, or group by time upper body endurance differences for male participants was partly accepted and partly rejected. The portion dealing with group was accepted, while the portions dealing with time and group by time was rejected.
- 12. The twelfth hypothesis which stated that there would be no significant group, time, or group by time upper body endurance differences for female participants was partly accepted and partly rejected. The portion dealing with group was accepted, while the portions dealing with time and group by time was rejected.

### Potential Applications

The purpose of the present study was to investigate differences in rest periods between sets in strength training. Based on the results, two potential applications are prescribed. First, for the individual wanting to significantly improve his or her strength, a resistance training program utilizing a rest period of no longer than 30 seconds is recommended. By keeping rest periods <30 seconds, the individual will force additional motor units within the muscle to be activated due to fatigue setting in. This additional usage throughout a period of time will cause faster and greater strength gains in the muscles used.

The second recommendation is for the individual wanting to significantly improve his or her muscular endurance. This individual is prescribed a resistance training program which employes a rest period of at least 90 seconds. The long rest between sets allows the motor units enough time to rejuvenate before being called upon again. As a result, this rest builds endurance in the muscle. Resting between sets for at least 90 seconds throughout a training program will cause greater endurance gains in the muscles used.

### Recommendations

The experience and knowledge gained by this investigator leads to the following recommendations concerning this and possible future studies:

- 1. It is recommended to further investigate differences within male and female groups in somatotype, body weight, strength, endurance, body composition, and measurements in relation to rest periods between sets in strength training, by lengthening the testing period to 15 to 20 weeks.
- 2. It is recommended to identify other strength and endurance tests and to compare results with this investigation for the same age range.
- It is recommended to further analyze the views of neural mechanisms determining strength increases.

- 4. It is recommended to conduct strength and endurance measures on computerized strength equipment.
- It is recommended to examine different, perhaps smaller, rest periods to increase possible comparisons.

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Table 1

AGE AND PHYSICAL CHARACTERISTICS OF MALE SUBJECTS

Male Subjects						
Variables	30 Second Rest Group	90 Second Rest Group	Control Group			
Age, years	19.7	19.4	20.2			
Height, in	$69.7 \pm 3.4$	$70.0 \pm 2.6$	$70.6 \pm 3.4$			
Weight (Pretest)	$183.8 \pm 27.7$	$176.6 \pm 16.2$	$189.6 \pm 13.1$			
Weight (Posttest)	$182.6 \pm 24.4$	$176.0 \pm 13.1$	$189.0 \pm 13.3$			
% Body Fat (Pretest)	$14.1 \pm 5.2$	$11.6 \pm 4.0$	$10.4 \pm 1.9$			
% Body Fat	$11.7 \pm 4.8$	$9.6 \pm 5.3$	$10.1 \pm 2.1$			
(Posttest)						
BMI (Pretest)	$26.7 \pm 3.3$	$25.4 \pm 2.3$	$26.9 \pm 2.7$			
BMI (Posttest)	$26.5 \pm 2.9$	$25.4 \pm 2.1$	$26.9 \pm 2.8$			
Bench 1 RM	$146.1 \pm 26.1$	$143.3 \pm 25.5$	$161.4 \pm 9.9$			
(Pretest)						
Bench 1 RM	$183.3 \pm 25.5$	$171.7 \pm 22.9$	$162.1 \pm 10.7$			
(Posttest)						
Leg 1 RM (Pretest)	$193.3 \pm 32.1$	$191.7 \pm 27.6$	$162.1 \pm 10.7$			
Leg 1 RM (Posttest)	$231.1 \pm 31.0$	$219.4 \pm 24.4$	$164.3 \pm 12.4$			
Bench Endurance	$14.7 \pm 7.1$	$14.3 \pm 4.2$	$24.3 \pm 3.4$			
(Pretest)						
Bench Endurance	$21.9 \pm 5.8$	$27.0 \pm 4.6$	$25.1 \pm 3.9$			
(Posttest)						

Table 2

AGE AND PHYSICAL CHARACTERISTICS OF FEMALE SUBJECTS

Female Subjects						
Variables	30 Second Rest Group	90 Second Rest Group	Control Group			
Age, years	19.2	19.2	20.1			
Height, in	$67.7 \pm 3.6$	$66.1 \pm 3.3$	$65.9 \pm 1.8$			
Weight (Pretest)	$150.2 \pm 38.4$	$140.4 \pm 18.5$	$146.7 \pm 15.5$			
Weight (Posttest)	$148.2 \pm 35.1$	$138.1 \pm 16.4$	$146.3 \pm 15.1$			
% Body Fat	$22.2 \pm 4.4$	$22.8 \pm 3.8$	$22.7 \pm 4.8$			
(Pretest)						
% Body Fat	$20.3 \pm 4.4$	$21.0 \pm 3.2$	$22.6 \pm 4.4$			
(Posttest)						
BMI (Pretest)	$23.1 \pm 3.4$	$22.5 \pm 1.5$	$23.8 \pm 2.1$			
BMI (Posttest)	$22.6 \pm 3.0$	$22.2 \pm 1.4$	$23.7 \pm 2.0$			
Bench 1 RM	$86.7 \pm 20.3$	$89.1 \pm 22.8$	$73.6 \pm 18.6$			
(Pretest)						
Bench 1 RM	$123.8 \pm 21.9$	$114.5 \pm 25.9$	$75.0 \pm 17.1$			
(Posttest)						
Leg 1 RM	$132.5 \pm 20.6$	$129.5 \pm 20.9$	$117.9 \pm 7.6$			
(Pretest)						
Leg 1 RM	$171.7 \pm 20.9$	$156.8 \pm 21.0$	$120.0 \pm 7.6$			
(Posttest)						
Bench Endurance	$17.5 \pm 6.0$	$16.4 \pm 9.0$	$21.9 \pm 4.4$			
(Pretest)						
Bench Endurance	$25.5 \pm 4.5$	$27.4 \pm 7.8$	$22.7 \pm 4.1$			
(Posttest)						

Table 3 ANALYSIS OF VARIANCE RESULTS FOR BODY WEIGHT FOR MALES

Male Subjects	<b>3</b> 0			
Source	SS	df	MS	$\mathbf{F}$
Group	1349.0	2	674.5	0.91
Error	16273.0	22	739.7	
Time	7.6	1	7.6	0.93
Group X Time	1.2	2	0.6	0.08
Error	178.8	22	8.1	
Total	17809.6	49		

Table 4

ANALYSIS OF VARIANCE RESULTS FOR BODY WEIGHT FOR FEMALES

Female Subjects				
Source	SS	df	MS	F
Group	1189.3	2	594.6	0.42
Error	38123.8	27	1412.0	
Time	33.6	1	33.6	1.67
Group X Time	7.7	2	3.9	0.19
Error	544.4	27	20.2	
Total	39898.8	59		

Table 5

ANALYSIS OF VARIANCE RESULTS FOR PERCENT BODY FAT FOR MALES

Male Subjects	•			
Source	SS	df	MS	F
Group	68.1	2	34.1	1.00
Error	753.0	22	34.2	
Time	28.9	1	28.9	14.52**
Group X Time	10.3	2	5.2	2.59
Error	43.7	22	2.0	
Total	904.0	49		

<sup>\*\*</sup> significant at the .01 level.

Table 6

ANALYSIS OF VARIANCE RESULTS FOR PERCENT BODY FAT FOR FEMALES

Female Subjects	<del>5</del> 6			
Source	SS	df	MS	F
Group	17.6	2	8.8	0.26
Error	903.5	27	33.5	
Time	22.3	1	22.3	20.63**
Group X Time	8.3	2	4.1	3.82*
Error	29.2	27	1.1	
Total	980.9	59		

<sup>\*</sup>significant at the .05 level.

Female Subjects		
Rest	Te	est
	Pre	Post
0.5	22.2	20.3
1.5	22.8	21.0
C	22.7	22.6

<sup>\*\*</sup>significant at the .01 level.

Table 7

ANALYSIS OF VARIANCE RESULTS FOR BODY MASS INDEX FOR MALES

Male Subjects				
Source	SS	df	MS	F
Group	21.7	2	10.63	0.73
Error	321.22	22	14.60	
Time	0.12	1	0.12	0.69
Group X Time	0.03	2	0.01	0.09
Error	3.82	22	.17	
Total	346.46	49		

Table 8

ANALYSIS OF VARIANCE RESULTS FOR BODY MASS INDEX FOR FEMALES

Female Subjects				
Source	SS	df	MS	F
Group	16.6	2	8.3	0.72
Error	314.0	27	11.6	
Time	1.4	1	1.4	4.81*
Group X Time	0.4	2	0.2	0.79
Error	7.6	27	0.3	
Total	340.0	59		

<sup>\*</sup>significant at the .05 level.

Table 9

ANALYSIS OF VARIANCE RESULTS FOR 1 RM LEG PRESS FOR MALES

Male Subjects	-			
Source	SS	df	MS	F
Group	21428.6	2	10714.3	8.34**
Error	28248.4	22	1284.0	
Time	6276.8	1	6276.8	780.24**
Group X Time	2590.0	2	1295.0	160.98**
Error	177.0	22	8.0	
Total	58720.8	49		

<sup>\*\*</sup>significant at the .01 level.

Male Subjects		
Rest	To	est
	Pre	Post
0.5	193.3	231.1
1.5	191.7	219.4
C	162.1	164.3

Table 10

ANALYSIS OF VARIANCE RESULTS FOR 1 RM LEG PRESS FOR FEMALES

		200		
Female Subjects				
Source	SS	df	MS	F
Group	9872.6	2	4936.3	7.22**
Error	18469.5	27	684.1	
Time	7416.5	1	7416.5	399.41**
Group X Time	3040.7	2	1520.4	81.88**
Error	501.4	27	18.6	
Total	39300.7	59		

<sup>\*\*</sup>significant at the .01 level.

Female Subjects		
Rest	Te	est
	Pre	Post
0.5	132.5	171.7
1.5	129.5	156.8
C	117.9	120.0

Table 11

ANALYSIS OF VARIANCE RESULTS FOR 1 RM BENCH PRESS FOR MALES

Male Subjects	•			
Source	SS	df	MS	F
Group	474.0	2	237.0	0.25
Error	21054.0	22	957.0	
Time	6014.7	1	6014.7	502.19**
Group X Time	2768.5	2	1384.2	115.58**
Error	263.5	22	12.0	
Total	30574.7	49		

<sup>\*\*</sup>significant at the .01 level.

Male Subjects	\$ ~	
Rest	Te	est
	Pre	Post
0.5	146.1	183.3
1.5	143.3	171.7
C	161.4	162.1

Table 12 ANALYSIS OF VARIANCE RESULTS FOR 1 RM BENCH PRESS FOR **FEMALES** 

Female Subjects	<b>7</b> 0			
Source	SS	df	MS	F
Group	9347.2	2	4673.6	5.10*
Error	24731.6	27	916.0	
Time	6451.8	1	6451.8	220.31**
Group X Time	2818.1	2	1409.0	48.12**
Error	790.7	27	29.3	
Total	44139.4	59		

Female Subjects				
Rest	Test			
	Pre	Post		
0.5	86.7	123.8		
1.5	89.1	114.5		
C	73.6	75.0		

<sup>\*</sup>significant at the .05 level.

\*\*significant at the .01 level.

Table 13  $\label{eq:analysis} \mbox{ANALYSIS OF VARIANCE RESULTS FOR BENCH PRESS ENDURANCE FOR } \mbox{MALES}$ 

Male Subjects	<del>.</del> 20			
Source	SS	df	MS	F
Group	328.4	2	164.2	3.33
Error	1084.0	22	49.3	
Time	589.5	1	589.5	234.90**
Group X Time	274.8	2	137.4	54.75**
Error	55.2	22	2.5	
Total	2331.9	49		

<sup>\*\*</sup>significant at the .01 level.

Male Subjects	•	
Rest	To	est
	Pre	Post
0.5	14.7	21.9
1.5	14.3	27.0
C	24.3	25.1

Table 14

ANALYSIS OF VARIANCE RESULTS FOR BENCH PRESS ENDURANCE FOR FEMALES

Female Subjects				
Source	SS	df	MS	F
Group	5.5	2	2.8	0.03
Error .	2158.0	27	79.9	
Time	621.7	1	621.7	179.68**
Group X Time	223.2	2	111.6	32.26**
Error	93.4	27	3.5	
Total	3101.8	59		

<sup>\*\*</sup>significant at the .01 level.

Female Subjects			
Rest	Test		
	Pre	Post	
0.5	17.5	25.5	
1.5	16.4	27.4	
C	21.9	22.7	

Figure 1
CYBEX Leg Extension Machine



Figure 2
CYBEX Leg Curl Machine



Figure 3
CYBEX Horizontal Leg Press Machine



Figure 4

CYBEX Smith Machine (for Bench Press)



Figure 5

CYBEX Bicep Curl Machine



Figure 6
CYBEX Tricep Extension Machine

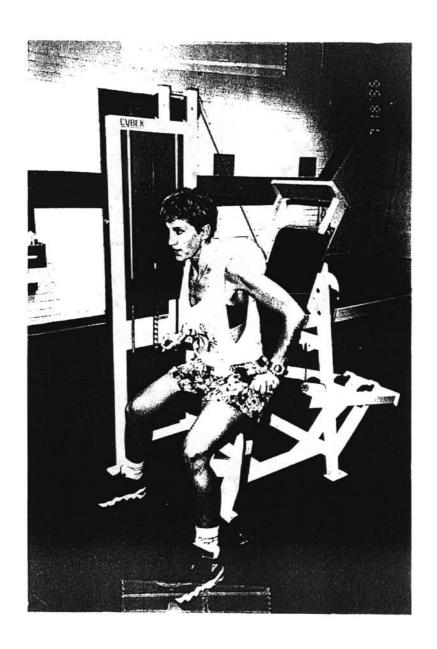


Figure 7

CYBEX Lat Pull Machine



Figure 8

CYBEX Rear Row Adductor Machine



## Appendix A PAR-Q Form

NAME					Date of Birth		
CURRENT	ADE	DRES	SS_				
In case of e	merge	ency,	пап	ne and telephone of person to	contact phone		
- 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	merge	ency	wha		related to medical personnel (such as		
allergies, a					cutes to means process (see as		
250				PAR Q & Y	 ⁄ου		
PAR-Q is completion in your life	design of PA1	ned to K-Q is	help a sei	you help yourself. Many health be asable first step to take if you are pl	nefits are associated with regular exercise, and the anning to increase the amount of physical activity		
the small nu advice conc Common	imber eming sense wer op	of adu the ty is you posite	ilts fo ype o ir be:	or whom physical activity might be of activity most suitable for them.	m or hazard PAR-Q has been designed to identify e inappropriate or those who should have medical destions. Please read them carefully and check the		
	1 cs	No	,		and have been been ble?		
	D		2	Has your doctor ever said y  Do you frequently have pair			
		0	3		ive spells of severe dizziness?		
		Ö	4		blood pressure was too high?		
	П		5.		ou that you have a bone or joint problem		
			3.		an aggravated by exercise or might be		
				made worse with exercise?	en aggravated by exercise of finght be		
			ř.		son not montioued house where the 14		
, k			6		son not mentioned here why you should		
_			7	not follow an activity progra			
If you	u	U	7.	Are you over age 65 and not	t accustomed to vigorous exercise?		
answered	•	Yes	to o	ne or more questions	No to all questions		
7	tele ing ing sici "ye	t with phon your a fitr an w	n yo ne or phy ness hat on	not recently done so, con- ur personal physician by in person before increas- ysical activity and/or tak- appraisal. Tell your phy- questions you answered PAR-Q or present your	If you answered PAR-Qaccurately, you have reasonable assurance_of your present suitability for  • a graduated exercise program—a gradual increase in proper exercise promotes good fitness development while minimizing or eliminating discomfort—and		
	(11)		41	Programs	a fitness appraisal—the Canadian Standardized Test of Fitness (CSTF).		
	from		ur p	al evaluation, seek advice hysician as to your suit-	Postpone		
	• t	nres ng o gradu restric neet j	trict off chally red your	ed physical activity start- easily and progressing , and or supervised activity to r specific needs, at least on basis. Check in your com- r special programs or ser-	(If you have a temporary minor illness, such as a common cold		

# Appendix B. Somatotype Rating Form

	HEATH	CARTER S	OMATOTYPE R	ATING FORM			
new DC			Aut 23.6	51 4 14	0	96	
occurrence Phys	Ed. Student		China Legion		5 m 1 t	May 193	
PROJECT ATP				of ASURT	·11. 2.C		
Sentods one i			****	onersy ps			
1-ares = 24.0	Hoper 10 9 14.9 18.9 77 9	26 9 31 2 35 8	16.7 <b>46.</b> 7 % 7 % 7	45 / 71 7 81 7 89 2	6 4 102 4 154	3317 157 7 1	17. : 187 9 204 0
Salk apply : 10 4	Mid- sount	/50.St 315	16 0 (1) : · · · · · · · · · ·	5. 0 69 S 10 0 85 S	94 (0 1004 (0 1) 4 (	. : 5 (3/1) 450 5 )	61 C 180 D 196.D
Subratias : F. 9	1.0-01 0110150190	25 0 27 6 31 3	P. S. 40 S. D. 1 N. J.	5c : 65 \$ 72 3 31 3 1	STE 94 2 179 S		5: 3 172 0 188.0
101AL SKINFOLDS : 73.4	Lond Cite 150 150						
Call = /7 /							
	COMPONEN. I 11 )	P. S. Pa	, O , ,	c ** / *;		c 10 13.1	11 115 12
Height ta 1 = 64.8	55.0 SE.5 SB.0 59.5 61.0	62.5 6: 3 65.5	610 GE : 10 715	110 145 760 22	5 190 305 3		5 5 88.0 89 5
Bone: Humerus = 2.03	5.19 5.34 5.49 5.64 5.78	5.93 (6.22	E37.53.19.680	: 95 7.09 1.2: :	8 751 757	31 197 E11 8.	25 E 40 8 55
femur = 9.33	7,41 152 7,83 8,04 8,24	8.45 8.66 5.87	9.38 @ 9 : 1 5 18	9 91 10 17 16 31 19 1	ST 16 24 15 m	11 17 11 56 11	15 12 00 17 71
Musc'r. Biceps += 27.4	23 7 (2 1 25.0 25.7 26.3	210@253	29 G 29 L. 1 11 G	85 177 B 18	5 30 3 35 ; ]	163 371 37	E 15 5 19.1
Call # = 36.4	27.7 35.5 29.3 30 1 30.8	31,6 33.7	93 9 34 Tin 5 📵	): 1 3/3 10 19	2 26 7 21 7 2	1 5 47.6 43 4 44	1.7 15.0 45.8
*38.1-1.7*	SECOND TO I	2 )	1 11 1	. 0/ 5		7 79 1	
Weight 110. : 1370	Upper limit 11.99 12.	37 12 53 12 74	17 95 .3 .3 .3 36	.1 56 13 () 13 98 1	4 19 14 39 10 10	22 SC 15 01 15.72	2 (5 42 15.63
HI 3/N: 1256	Mid-point and 12	16 17 17 17 64	12.85	.3 46 13.67 13.38 1	: 01 14 75 14 5.	: :0 14 91 15.17	2 15 33 15.53
	Lower time! below 12.	00 12 33 (12.54)	)17 45 ii. + ii 16	3.31 13.56 13.13 1	1.99 14 76 12 2	14 50 14 81 15 00	7 15 21 15 43
	THIRD COMPONENT	r: ①	1 2 1		5'1 6 5	1 Pr •	15 1
		COMPONEN	1 (24) 2010	IMIRS COMPONENT	Ι,	4	
	Anthrockmetric Somatotype	4%	5	2	87	C	
	Anthropynetric plus Photoscopic Somatotype				RATER		100

Heath-Carter Somatotype Rating Form

### Appendix C. Determining the Endomorphic Component

Following are the steps to determine the endomorphic component

- Sum the obtained values from the following skinfold measurements triceps, subscapular, and suprailiac.
- 2. The second step is to find where the closest value equaling the sum is on the total skinfold scale. The first component for that column is circled.

### Appendix D. Determining the Mesomorphic Component

Following are the steps to determine the mesomorphic component:

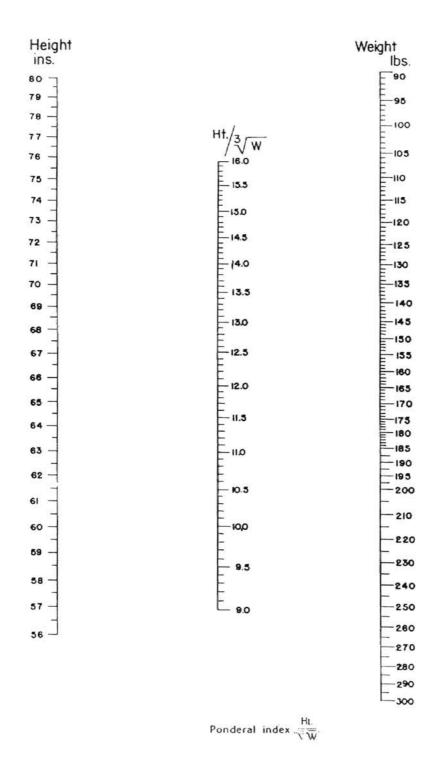
- 1. Place an arrow above the column containing the subject's height.
- 2. For the two bone measurements (humerus and femur breadth), circle the closest figure in the appropriate row. Where a decision must be made to circle either a higher or a lower number, circle the one which is closer to the height column.
- Subtract the triceps skinfold from the biceps circumference. To do this, first convert the triceps to centimeters by moving the decimal point one place to the left.
- 4. Now subtract the calf skinfold from the calf circumference. Again, change the calf skinfold to centimeters by moving the decimal point one place to the left.
- Circle these two corrected measurements in their proper rows.
- 6. Using the height column as the starting column, count the number of columns each other circled value deviates from this starting point. The average deviation of these measurements equals the total divided by four. This represents the average deviation from the height column.
- 7. Take the average deviation from the height column and add 4. This value gives the obtained final value for the second component.

### Appendix E. Determining the Ectomorphic Component

Following are the steps to determine the ectomorphic component:

- 1. Determine the Ponderal index, which is the height divided by the cube root of the weight by using Appendix F, and record this value.
- 2. On the somatotype rating form, circle the closest value and note the somatotype in the third component row under the column.

Appendix F. Pondural Index



### Appendix G

### OKLAHOMA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD HUMAN SUBJECTS REVIEW

Date: February 18, 1998 IRB #: ED-98-074

Proposal Title: A COMPARISON OF TWO DIFFERENT REST PERIODS BETWEEN SETS OF A STRENGTH TRAINING PROGRAM INVOLVING COLLEGE STUDENTS

Principal Investigator(s): Frank A. Kulling, Barbara Reed-Hardison

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.

APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.

ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

#### Comments, Modifications/Conditions for Approval or Disapproval are as follows:

The reviewer has no problem recommending approval of this proposal on an exempt status. Since the research will be performed at other institutes, he/she questions whether either St. Gregory's or East Central University might have their own requirements regarding Institutional Review for research involving human subjects

Chair of Institutional Review Board

ce: Barbara Reed-Hardison

Date February 20, 1998

#### VITA

### Barbara L. Reed-Hardison

### Candidate for the Degree of

### Master of Science

Thesis: COMPARISON OF 30 AND 90 SECOND REST PERIODS BETWEEN SETS OF A RESISTANCE TRAINING PROGRAM

Major Field: Health, Physical Education, and Leisure

Biographical:

Personal Data: Born in Santa Ana, California, on May 13, 1969, the daughter of Betty and Stan Reed.

Education: Graduated from Tecumseh High School, Tecumseh, Oklahoma in May 1987; received a Bachelor of Science degree in Physical Education and a Bachelor of Art degree in English from East Central University, Ada, Oklahoma in August 1992. Completed the requirements for the Master of Science degree with a major in Exercise Science at Oklahoma State University in May 1998.

Experience: Currently employed as the Wellness Center director and part-time faculty member (department of Health, Physical Education, and Recreation) at East Central University in Ada, Oklahoma (1997-Present). Previously employed as the assistant director of the Mabee Aerobic Center, part-time faculty member (department of Health, Physical Education, and Recreation), and assistant women's basketball coach at St. Gregory's College in Shawnee, Oklahoma (1993-1997).

<u>Professional Memberships.</u> American Alliance for Health, Physical Recreation and Dance, Oklahoma Alliance for Health, Physical Recreation and Dance.