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ANAEROBIC POWER GAINS IN
FEMALES AS A RESULT
OF WEIGHT TRAINING

A Thesis

by

DAVID ALAN WARD

Submitted to the Graduate School
Appalachian State University
in partial fulfillment of the requirements
for the degree of
MASTER OF ARTS

June 1984

Major Department: Health, Physical Education, and
Recreation

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David Alan Ward

June 1984

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ABSTRACT

ANAEROBIC POWER GAINS IN FEMALES AS A RESULT
OF WEIGHT TRAINING (June 1984)

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The purpose of this study was to investigate the anaerobic power gains in females as a result of an eight-week weight training program. Sixteen females participated in an eight-week weight training program that involved lifting weights three times a week for approximately 45 minutes per workout.

The testing procedures utilized in this study included four performance evaluation periods; T_1 , T_2 , T_3 , and T_4 . Tests included were: absolute strength measures (1-RM Bench Press, 1-RM Parallel Squat, and 1-RM Deadlift), body composition measures, and vertical jump measures. Anaerobic power was predicted utilizing the body weights and vertical jump measures of each subject. Analysis of Variance with repeated measures was performed to determine whether significant differences occurred across evaluation periods.

The findings of the study support the following conclusions:

1. The weight training protocol utilized in the present study was sufficient to realize significant increases in absolute strength measures taken.

2. The weight training protocol utilized in the present study was sufficient to realize significant increases in lean body weight and decreases in percent of body fat.

3. The weight training protocol utilized in the present study was sufficient to realize significant increases in anaerobic power.

ACKNOWLEDGEMENTS

The author would like to extend thanks to Dr. Michael Stone who encouraged me to conduct research on a much needed area. The author would also like to thank Dr. Robert Johnson, Dr. Vaughn Christian, and Harold O'Bryant for their leadership and guidance in the preparation, organization and completion of this study.

DEDICATION

The author would like to dedicate this study to Warren, Joyce, Dawn, Joy, and Pat. Thank you for your love, patience, and understanding throughout the writing of this thesis.

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CHAPTER ONE

INTRODUCTION

Exercise has been a vital component in the daily activities of many Americans. Valuable leisure time has been utilized through participation in activities that improve physical well-being. Men and women alike have become aware of the tremendous benefits of routine exercise.

The general public has been interested in the physiological advantages of various modes of physical activity. Scientific evidence has revealed significant gains in strength, power, and endurance as a result of weight training (29: 75). Weight training has become a popular method of maintaining overall fitness among males and females.

Significant emphasis has been placed on women's sports and athletics during the past decade (22: 79). Ruling bodies and organizations have been formed to govern the activities of the female athlete. The participation of women in sport has continued to grow in America and in nations throughout the world.

The physiological responses of the female athlete to various training programs have been a major concern

of coaches and athletes in recent years. Coaches and athletes alike have been interested in the methods and techniques that induce optimal performances. Skill levels have already improved as a result of intense training practices and highly competitive sporting events (4, 12, 21, 22, 28).

The acquisition of strength through weight training has been vital in the success of many male athletes (4: 174). Strength training programs have been included in the training regimens of most male collegiate and professional teams. Consequently, female athletes might have benefited in a similar fashion if strength training had been incorporated into their athletic training programs (12, 21, 23, 28).

The exact changes that occur when females engaged in strength training have not been completely documented in the existing literature (4: 174). However, certain investigators have made interesting discoveries concerning females and strength training. Research has indicated that females have achieved significant increases in lean body weight and significant decreases in percentage body fat through weight training (12: 70). Research has also concluded that strength training produced significant changes in body composition without reducing body weight in females (12: 70). According to a study by Westcott in 1974, both males and females could have increased strength in the upper body between two and

six percent as a result of training with weights (27: 27).

Males and females have displayed no differences in strength when square centimeters of cross-sectional muscle have been compared. However, there have been obvious differences with respect to muscle size. Larger muscles have exhibited significant strength advantages. Muscle size has increased in males to a greater degree than increases in females as a result of strength training. The male sex hormone testosterone has appeared to be the reason for greater muscle hypertrophy in males (27: 27-28).

The differences that exist between men and women with regard to strength training need to be examined. Research has been minimal in this area. Without significant evidences supporting differences or similarities in the changes that occur in females as a result of strength training, it will be difficult to prescribe training programs for females interested in acquiring maximal gains in strength.

Statement of Purpose

The primary purpose of this study was to investigate the anaerobic power gains in college-aged females as a result of an eight-week weight training program. A secondary purpose was to investigate the absolute strength gains. A tertiary purpose was to investigate changes in body composition.

Statement of the Problem

What significant changes occur in power, strength, and body composition in females as a result of weight training?

Definition of Terms

Anaerobic power - The ability to have released a maximum force in the fastest possible time.

1-RM (One Repetition Maximum) - The highest workload that could have been lifted for one repetition.

Weight Training - A training method designed to develop strength, characterized by the use of lifting technique with heavy resistances.

Strength Training - Training programs including exertion against a resistance.

Limitations

The following were limitations for the study:

1. There was no control over the physical activities of the subjects other than the weight training program.

2. A control group was not utilized due to existing evidence supporting the effectiveness of weight training programs.

Delimitations

The study was delimited to include 16 individuals from the female population at Appalachian State University during Spring Semester of 1982. The study was

further delimited to test anaerobic power gains as a result of weight training.

Hypotheses

The Null Hypothesis. There were no significant increases in the anaerobic power levels of college-aged females as a result of an eight-week weight training program.

The Alternate Hypothesis. There were significant increases in the anaerobic power levels of college-aged females as a result of an eight-week weight training program.

Need for the Study

The opportunity for women to excel in athletics and sport has increased significantly. Organizational and administrative bodies have been formed to govern the activities of the female athlete. The skill level of the female athlete has risen to such a degree that equal attention has been warranted in regard to training methods and techniques (21: 110).

The advantages and benefits that males have enjoyed as a result of strength training have been adequately documented (4, 17, 22). Researchers have devoted many hours studying the effects of strength training in the male athlete. However, research has not adequately examined the effects of strength training in the female athlete (4, 17, 22, 28).

Research has been needed to insure women the same opportunity to achieve optimal performance in sport and athletics.

Basic Assumptions

The basic assumptions of the study were:

1. The sample of subjects was a reliable representation of the female population at Appalachian State University.
2. The human performance evaluations were performed accurately.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The overload principal has long been an essential component of resistance training. Strength gains have been induced by exceeding the normal demands placed on the body. Physiological adaptations have occurred as a result of stress on skeletal muscles during overload. Adaptations to stress or overload during resistance training have included increases in strength (27: 43).

Researchers have documented the positive physiological adaptations that have occurred as a result of resistance training (1, 2, 3, 8, 17, 20). However, coaches, athletes, and researchers have been skeptical of females involved in resistance training, specifically weight training (17, 22). Misconceptions related to muscle hypertrophy and weight gain have prevented many women from achieving significant gains in strength through weight training. The purpose of this study was to evaluate the anaerobic power gains that occurred in college-aged females as a result of an eight-week weight training program.

The review of literature in this chapter has included selected information related to:

1. Adaptations of Males to Strength Training
2. Adaptations of Females to Strength Training
3. A Summary of Related Literature.

Adaptations of Males to Strength Training

Researchers have documented gains in strength and muscle hypertrophy in males as a result of weight training (1, 2, 3, 8, 17, 20). Strength training has been used as the foundation for many sports training programs. The development of muscular strength and power through weight training has been an important factor in the improvement of performances in many areas of sport (27: 35-36).

Chui (7) (1950) studied the anaerobic power effects of 23 males involved in a weight training program. Subjects in the weight training group were compared to 22 male students that participated only in the regular physical education program at the University of Iowa. The weight training group increased in anaerobic power as a result of the weight training program. The student control group showed no consistent increases in anaerobic power as a result of the regular physical education program.

Barney and Bangster (1) (1961) investigated the effects of an eight-week isotonic leg lift program on 80 college-aged male subjects. Subjects were divided

into three groups. Specific variations of progressive resistance exercise were assigned as treatments for each group. All three methods of progressive resistance exercise resulted in significant strength gains. However, no significant differences in strength gains were recorded among the groups.

Berger (2) (1962) completed a study that investigated the optimum number of repetitions needed to induce strength gains. A 12-week progressive resistance exercise program employed 199 male college-aged students divided into nine groups. Each group trained using different numbers of repetitions. Berger (2) concluded training with three to nine repetitions in a set would result in optimum gains in strength.

O'Shea (2) (1966) studied the effects of selected weight training programs on strength and muscle hypertrophy. Three groups of 10 subjects per group were involved in a six-week progressive resistance training program. Subjects performed between two and ten maximum load repetitions using the full squat exercise. Performances were evaluated using thigh girth, static strength as measured on a dynamometer, and 1-RM using the full squat exercise. Improvements were recorded in all three groups in the full squat and dynamometer. However, no significant differences were discovered among the groups as a result of the various training routines.

Adaptations of Females to Strength Training

Studies have documented some of the changes that have occurred in females as a result of strength training (4, 17, 21, 28). Studies have also documented significant strength gains in males as a result of strength training (1, 2, 3, 8, 17, 20). The completed research that has investigated the physiological changes that have occurred in females as a result of strength training has presented recognizable improvements in strength (3, 4, 11, 13, 17, 21, 22, 26, 28, 29).

Montgomery (16) (1954) studied the effects of strength training on muscle hypertrophy in 10 female subjects. The six-week training period included exercising one arm slowly with weights and the other arm rapidly without weights. Montgomery (16) concluded significant increases did not occur as a result of the training program.

Bright, Capen, and Line (3) (1961) completed a study with 14 college-aged female physical education majors. Subjects trained with weights three times per week for a period of 10 weeks. High intensity resistances and low volume repetitions were used in the weight training program. Significant increases in strength, power, and muscular endurance were recorded as a result of the training program. Anthropometric measurements revealed no significant differences as a result of the training program.

Wells, Jokel, and Bahanen (26) (1963) investigated the effects of a four and one-half month physical training program on 14 year old girls. The physical training program included weight lifting. Strength increased 70 percent with an average weight loss of eight pounds as a result of the training program. Also, increases were found in lean body weight.

Brown (5) (1965) studied the effects of a five-week heavy resistance exercise program on 11 college-aged women. Subjects were divided into two groups. One group trained the upper body while the other group trained the lower body. Brown (5) recorded no significant changes in anthropometric measurements as a result of the five-week training program.

Hudson (11) (1966) completed a study on the effects of a 10-week weight training program on the strength and motor ability of 39 college-aged women. Pre-test and post-test strength values were recorded in grip strength, leg strength, back strength, pullups, and situps. Significant increases were found in leg strength, pullups, and situps. Increased were also recorded in grip and back strength; however, values were not significant.

Franci (11) (1968) studied the effects of a six-week overload and endurance program on 30 overweight college-aged women. Subjects were divided into two groups. One group used progressive resistance exercise with the 10-RM method. The other group used an endurance

program, beginning with 10-RM and increasing repetitions without increasing intensity. Both groups experienced decreases in body fat and increases in muscular density.

McKellar (18) (1970) investigated 86 physically underdeveloped high school girls who completed a six-week weight training program. Pre-test and post-test performance data were collected. Significant increases in the standing broad jump, bent knee pushup, and bent knee situp were discovered as a result of the weight training program.

Wilmore (28) (1974) completed a study with 47 females and 26 males engaged in a 10-week intense weight training program. Subjects attended an average of ten days per week, 40 minutes per session. Both groups performed the same weight training program. Exercises included: half squats, leg presses, toe raises, curls, bench presses, standing presses, bent arm pullovers, bent rows, and side bends. All lifts were performed seven to nine repetitions for two sets. Wilmore (28) made several conclusions. Both groups made similar gains in relative strength and absolute body compositions. The men were obviously stronger in all absolute strength measures. The women, however, demonstrated more leg strength in relation to lean body weight. The males experienced greater increases in muscle hypertrophy. Hypertrophy was detected however, in the upper extremities of both groups. Wilmore (28) further

concluded that hypertrophy was not always a result of strength training.

In a related study, Brown and Wilmore (4) (1974) reported the effects of maximal resistance weight training on strength and body composition of seven nationally ranked female track and field throwing event athletes aged 16 to 23 years. Five subjects trained three days per week for one to one-half hours using dumbbells, barbells, and a leg press. Exercises included: half squats, bench presses, lateral raises, and bent arm pullovers. The training program utilized increasing resistances with decreasing repetitions. Running, team sports, and technique work were also included in the program. Two of the seven subjects did not participate in the weight training program. Wilmore and Brown (4) found that subjects who trained with weights increased 15 to 44 percent in the bench press and 16 to 53 percent in the half-squat. Subjects that did not train with weights demonstrated very little improvement in strength. Wilmore and Brown (4) concluded females were able to participate in heavy resistance weight training and experience measurable strength gains without significant increases in muscle hypertrophy.

Mayhew and Gross (17) (1974) published a study related to body composition changes in women as a result of high intensity weight training. A nine-week

comprehensive weight training program included 17 college-aged females training three days per week, 40 minutes per workout. A circuit weight training routine was employed utilizing the Universal Gym Machine.* Subjects used the 10-RM technique on each of two sets. The results of the study indicated females experienced the same relative strength gains as males. Mayhew and Gross (17) concluded low androgen levels in females were the probable cause of insignificant gains in muscle hypertrophy.

Wilmore et al. (29) (1978) reported circuit training influenced increases in lean body weight, flexibility, strength, cardiovascular endurance, and influenced decreases in absolute and relative body fat.

Recently, Oyster (22) (1979) published a study related to the effects of heavy resistance weight training on the female athlete. A seven-week high intensity weight training program was performed by 14 champion tennis players at Ohio State University. Subjects trained on Nautilus Machines.** At the completion of the training program, subjects were tested and had increased in seven of nine strength measures. Significant strength increases were recorded in ankle plantar flexion and hip flexion. Decreases

*Universal Gym-Nissen Universal, Cedar Rapids, Iowa.

**Nautilus Sports/Medical Industries, Deland, Florida.

were found in all girth measurements. Oyster (22) concluded strength increases did not include significant changes in absolute body weight, skinfold, or girth measurements.

In another recent study, O'Shea and Wegner (21) (1981) researched the effects of power weight training on the female athlete. A power weight training program was conducted with 13 males and 13 females at Oregon State University. Subjects were volunteers and had taken a minimum of 10 weeks of beginning weight training. Workouts were conducted on Monday, Wednesday, and Friday for seven weeks, with a two-week preconditioning period. The program included the bench press and full squat and was similar to a power lifting program used by competitive male lifters. Proper technique was taught during the preconditioning period. Subjects performed between eight and twelve repetitions during this period on the bench press and full squat. Ten minutes of flexibility training, rounded back deadlifts, latissimus pulldowns, and front dumbbell lateral raises were performed to prevent injury. During the power training program, resistance loads were increased every Monday, five pounds on the bench press and ten pounds on the full squat. The women experienced significant increases in body weight and body fat with a small increase in lean body mass as a result of the program. Both groups experienced absolute strength gains in the bench press

and full squat. When strength gains in the full squat were expressed relative to body weight, the females experienced greater significant gains than the males. O'Shea and Wegner (21) concluded relative strength gains were not significantly related to muscle hypertrophy. A probable increase in caloric intake as a result of highly intense workouts, according to O'Shea and Wegner (21), may not have been exceeded by caloric expenditure and could have caused increases in the absolute body weight of the females.

Summary of Related Literature

The majority of early research conducted in strength training was devoted to the specific methods and techniques of training. Current research has investigated the effects of free weights, machines, and other modes of training that induce strength gains. Strength training has become scientific and specific in nature.

Early researchers conducted studies related to the acquisition of strength with male subjects. Most research endeavors associated with this area and during this period of time were directed at investigating the training methods and techniques of men in athletics and sport. Research studies have concluded that men experience increases in strength as a result of strength training (1, 2, 3, 8, 17, 20, 27).

Recently, women have become extensively involved in athletics and sport. Coaches and athletes alike have been interested in achieving optimal performances through productive training practices. The lack of relative literature concerning the specific changes that occur in females as a result of strength training has almost forced the female athlete to follow training routines utilized by males.

Research has indicated only some of the changes that occurred in females as a result of weight training (3, 4, 13, 17, 21, 22, 26, 28, 29). Increases in strength and lean body weight of females were reported in most studies (1, 4, 11, 13, 17, 18, 21, 22, 26, 28, 29). Decreases in absolute body weight and anthropometric measurements were found in other related studies (11, 22, 26, 29). The more recent studies have indicated females experienced gains in strength similar to males in almost every area tested, especially when values were expressed relative to body weight (4, 17, 21, 28).

Only one study, to the knowledge of the author, has investigated the changes that occur in females as a result of power weight training. O'Shea (21) conducted a study in 1981 that involved 13 females that participated in a power weight training program. O'Shea (21) however, did not include anaerobic power output measures.

Only one study, to the knowledge of the author, has investigated the changes that occur in females as a result of a weight training program that utilized periodization (16, 23, 24). Various combinations of lifting routines were mentioned in the review of literature of present study. However, not one utilized a decreasing volume, increasing intensity technique, over a period of eight to ten weeks.

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CHAPTER THREE

METHODS AND PROCEDURES

The purpose of this study was to investigate the anaerobic power gains in 16 college-aged females as a result of an eight-week weight training program. This chapter will outline the source of data, method of collecting data, training protocol, training equipment, testing procedures, and treatment of data.

Source of Data

The subjects used in this study were 16 college students (age 19.29 ± 1.35 years and weight 131.58 ± 18.23 pounds) from the female population of Appalachian State University. (See Appendix D.) The investigator presented a proposal to prospective subjects on the campus of Appalachian State University. An explanation of the purpose and outline of the study was given at that time. It was required that subjects could not have participated in a varsity sport on the collegiate level and could not have had any previous weight training experience.

Subjects that volunteered for the study were asked to sign a consent form prior to testing. (See Appendix A.)

Testing was scheduled immediately following the signing of consent forms.

A two-week instructional class was attended by the 16 females in the weight training group before the eight-week training program began. The purpose and procedures of the study were again presented in detail to solve any problems or clarify any questions that may not have been eliminated during the initial orientation meeting. Subjects were taught all the lifts that were included in the weight training program at this time. Warm-up and warm-down flexibility exercises were also taught during the two-week instructional period. Upon the completion of this instructional period, subjects were completely aware of the scope of the study, had practiced all the exercises included in the program, and were adequately prepared to participate in an eight-week lifting program.

Method of Collecting Data

The weight training program utilized in this study was similar to a program used by male lifters. The training program was for a period of eight weeks. Subjects trained three days per week on alternate days for approximately 45 minutes per workout. The training group consisted of college-aged female students.

Progress charts, performance data, and all raw data were recorded and filed into individual folders

for each subject. (See Appendix A.) Subjects were given their individual folders upon arrival to each workout and were responsible for recording completed repetitions and sets. Performance testing and raw data were collected and recorded by the investigator during testing sessions. (See Appendix A.) All testing was completed at the Human Performance Laboratory and the Wey Free Weight Facility at Appalachian State University.

Training Protocol

The eight-week weight training program used in this study was designed to emulate training methods used by male lifters. The training program was adapted from Matveyev's (13) Periodization Model (See Appendix B.) and the Hypothetical Model for Strength training by Stone et al. (23). (See Appendix B.) The modified periodization strength training program utilized in this study was characterized by low intensity resistances and high volume repetitions in the early stages and high intensity resistances and low volume repetitions in the final stages.

The training protocol required the completion of nine different exercises. Exercises included: parallel squats, bench presses, dead lifts, hamstring curls, latissimus pull downs, shoulder presses, biceps curls, tricep presses and crunch situps. The training program was designed with the three competitive power lifts

(bench press, parallel squat, deadlift) as the primary exercises. The remaining exercises were supplemental to the three major lifts.

The eight-week modified periodization program was divided into four phases:

1. The Hypertrophy Phase (2 weeks)
2. The Basic Strength and Power Phase (3 weeks)
3. The Strength and Power Phase (2 weeks)
4. The Peaking or Maintenance Phase (1 week).

The number of weeks, days, sets, repetitions, resistances, and volumes were adapted from the Periodization Model by Stone et al. (23).

Subjects trained on Mondays, Wednesdays, and Fridays for eight weeks, approximately 45 minutes per workout. Each workout was preceded by a 5-10 minute warm-up flexibility period. A 5-10 minute flexibility warm-down period was encouraged after every training session. (See Appendix B.)

The 16 female training subjects were divided into groups of two or three and followed a counterbalanced exercise routine. (See Appendix B.) Exercises were completed in a rotating order (counterbalanced) to prevent a particular group or groups of subjects from having a training advantage. Approximately five minutes were allowed for all subjects in a group to complete the required number of sets and repetitions. Every repetition in every set was performed with maximum resistance loads.

Training Equipment

The weight training program in this study utilized constant resistance equipment. York* Olympic barbells and dumbbells were used for performing the exercises. Fixed weight barbells were also used for some exercises. Each Olympic bar weighed 45 pounds and plates ranged from 2-1/2 to 45 pounds. Fixed weight barbells ranged from 40 to 130 pounds. Dumbbells weighed between 2-1/2 and 100 pounds. Two standard squat racks and two standard benches were used for squatting exercises and bench pressing exercises respectively. A 6' x 6' x 4' flat wooden platform was used for deadlift exercises.

Testing Procedures

The testing procedures used in this study included four performance evaluation periods; T_1 , T_2 , T_3 , and T_4 . Pre-tests (T_1) and post-tests (T_2) were performed during the first four weeks of training, and pre-tests (T_3) and post-tests (T_4) were performed during the second four weeks of training. Subjects encountered a one-week rest period between the fourth and fifth weeks of training as a result of Spring Semester Break that dismissed the entire student population at Appalachian State University. Subjects were instructed to rest during this period and encouraged not to engage in any type of formal or structured training activities.

*York Barbell Company, York, Pennsylvania.

All testing was performed at the Human Performance Laboratory or the Wey Free Weight Facility at Appalachian State University by the same testers at every testing period. Tests included were: height and weight, absolute strength measures, body composition, and vertical jump.

The weight of each subject was determined using a Healthometer Scale*. Weights were recorded to the nearest one-quarter pound.

A two-week instructional period was used to introduce subjects to the training program and testing procedures. Absolute strength measures were evaluated using the 1-RM method on the bench press, parallel squat, and deadlift. Proper form and technique were taught during this period. The bench press, parallel squat, and deadlift testing were in accordance with the 1979 International Federation Powerlifting Rule Book**. A trial and error method was employed to assist subjects in attempting maximal lifts. The investigator suggested attempting a lift 25 percent greater than a weight that could have been lifted 8-12 repetitions.

Body composition was determined using skinfold thicknesses on two selected sites on the body of each

*Healthometer Scale was manufactured by Continental Scale Corporation of Bridgeview, Illinois.

**Official Rules of the International Powerlifting Federation AAU-TPBA. Cedar-Hill, Texas, 1979.

subject. One measurement was taken on the back of the right arm, between the acromion and olecranon processes. The other measurement was taken on the highest point on the arch of the iliac crest on the right side of the body.

Skinfold readings were taken to the nearest .5 millimeter using the John Bull Harpenden Skinfold Caliper*. Two values for each skinfold measurement were taken and averaged for one mean value. The data were collected and analyzed in the Human Performance Laboratory at Appalachian State University using the Texas Instruments - 59 Calculator**. The Sloan Formula (See Appendix E.) for predicting percent of body fat in females was utilized.

Vertical jump measurements were recorded using the jump and reach test with the training group on four occasions during the training program. Subjects were allowed three trials of vertical jumping ability and a mean value of the jumper was used as the criterion measurement. A maximum of one minute was allowed between jump trials (14: 210-211). The Lewis Formula was utilized to predict anaerobic power from body weight and vertical jump. (See Appendix F.)

*John Bull Harpenden Skinfold Caliper was manufactured by British Indicators Limited of England.

**Manufactured by: Texas Instruments Incorporated, Dallas, Texas.

The following guidelines were used during the jump and reach testing sessions:

1. Each subject stood with the right side of the body next to the wall where the calibrated vertical jump board was mounted.

2. Feet were approximately shoulder width apart.

3. The left arm was held in place behind the back of each subject.

4. Each subject was instructed to extend the right hand on the calibrated vertical jump board as high as possible to establish a baseline stand and reach value.

5. Fingertips were chalked on the right hand to aid in accurate measurement of the jump and reach.

6. No preliminary foot movements were allowed before jumping.

7. Subjects were instructed to flex at the knees, jump as high as possible, and touch the calibrated vertical jump board at maximum height with the right fingertips.

8. The jump and reach value minus the stand and reach value equaled the vertical jump value.

Treatment of Data

The purpose of this study was to investigate anaerobic power gains in college-aged females as a result of an eight-week weight training program. Vertical jump measurements were recorded during T_1 , T_2 , T_3 , and T_4 . Absolute strength measures were recorded during T_1 and T_4 . (See Appendix C.)

Analysis of Variance with Repeated Measures was used to analyze the data across trials. BMDP Version 2V was utilized in the analysis*. The alpha level was preset at .05.

*Dixon, W. J. BMPD Statistical Software.
Berkeley: University of California Press, 1981.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF DATA

The purpose of this study was to investigate anaerobic power gains in college-aged females as a result of an eight-week weight training program. The purpose of this chapter was to examine the results of the study through an analysis of data. The analysis of data included analysis of anaerobic power, analysis of absolute strength measures, and an analysis of body composition. (See Appendix C.)

Data were collected during the Spring Semester of 1982 at Appalachian State University. Subjects were tested on four separate occasions during the training program: before the training began (T_1), after the fourth week of training (T_2), before the fifth week of training (T_3), and at the conclusion of the eight-week training program (T_4). Means and standard deviations were calculated. An Analysis of Variance with repeated measures was used to determine if significant changes occurred in anaerobic power, absolute strength, and body composition as a result of the eight-week lifting program. (See Appendix C.)

Analysis of Power Values

The mean values for the Experimental Group T_1 , T_2 , T_3 , and T_4 were 1680.33 foot-pounds/second \pm 180.60 foot-pounds/second, 1755.16 foot-pounds/second \pm 190.54 foot-pounds/second, 1740.87 foot-pounds/second \pm 204.69 foot-pounds/second, and 1774.80 foot-pounds/second \pm 172.31 foot-pounds/second, respectively. The Repeated Measures Analysis of Variance yielded a significant difference among treatments ($F = 14.87$, $p \leq 0.05$). The findings for the Analysis of Variance may be found in Table I. The Tukey post hoc test was performed to determine among what treatments the significant difference existed. The alpha level for the Tukey test was .05. The computed Tukey value was 54.38 foot-pounds/second. This value yielded significant differences between T_1 (1680.33 foot-pounds/second) and T_2 (1755.16 foot-pounds/second), T_1 (1680.33 foot-pounds/second) and T_3 (1740.87 foot-pounds/second), and T_1 (1680.33 foot-pounds/second) and T_4 (1774.80 foot-pounds/second). The findings for the Tukey post hoc test may be found in Table II.

TABLE I
ANALYSIS OF VARIANCE FOR ANAEROBIC POWER

Source	SS	df	MS	F	P
Treatment	242551.62	3	80850.54	14.87	.00
Error	391429.22	72	5436.52		

TABLE II
TUKEY POST HOC TEST ($t = 54.38$ $p \leq .05$)

Anaerobic Power Mean Value (foot-pounds/second)				
1774.80 ft.lbs./sec.	-	33.93	19.64	94.47
1740.87 ft.lbs./sec.	-	-	14.29	60.54
1755.16 ft.lbs./sec.	-	-	-	74.83
1680.33 ft.lbs./sec.	-	-	-	-

Analysis of Absolute Strength Measures

The mean values for 1-RM Bench Press in the Experimental Group T_1 and T_4 were 60.29 pounds \pm 12.05 pounds and 86.47 pounds \pm 14.12 pounds, respectively. The Repeated Measures Analysis of Variance yielded a significant difference between T_1 and T_4 ($F = 437.02$, $p \leq 0.05$).

The mean values for the 1-RM Parallel Squat in the Experimental Group T_1 and T_4 were 82.94 pounds \pm 19.77 pounds and 144.71 pounds \pm 26.72 pounds, respectively. The Repeated Measures Analysis of Variance yielded a significant difference between T_1 and T_4 ($F = 415.55$, $p \leq 0.05$).

The mean values for the Deadlift in the Experimental Group T_1 and T_4 were 119.12 pounds \pm 13.72 pounds and 165.88 pounds \pm 26.17 pounds respectively. The Repeated Measures Analysis of Variance yielded a significant difference between T_1 and T_4 ($F = 73.46$, $p \leq 0.05$).

Analysis of Body Composition

The mean values for Percent Body Fat in the Experimental Group T_1 and T_4 were 20.22 \pm 3.63 percent of body fat and 18.42 \pm 3.16 percent of body fat, respectively. The Repeated Measures Analysis of

Variance yielded a significant difference between T_1 and T_4 ($F = 12.01, p \leq 0.05$).

CHAPTER FIVE

SUMMARY, FINDINGS, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the anaerobic power gains in college-aged females as a result of an eight-week weight training program. Sixteen females, enrolled at Appalachian State University during Spring Semester of 1982, participated in the study. Each subject participated in four separate testing sessions. Anaerobic power levels were recorded at four testing periods; T_1 , T_2 , T_3 , and T_4 . Body composition and absolute strength measures were recorded at T_1 and T_4 .

The Lewis Formula was utilized to predict anaerobic power from body weight and vertical jump. (See Appendix F.) Analysis of the anaerobic power values for T_1 , T_2 , T_3 , and T_4 were performed to identify any significant increases in anaerobic power output. Means and standard deviations were calculated. An Analysis of Variance with Repeated Measures was used to determine significant changes that occurred. A

Tukey post hoc test was performed to determine the significant differences among treatments.

Findings

The findings of the study were as follows:

1. There was a significant increase ($p \leq 0.05$) in vertical jumps from T_1 (10.41 inches \pm 2.03 inches) to T_4 (11.43 inches \pm 1.87 inches).
2. There was a significant increase ($p \leq 0.05$) in anaerobic power from T_1 (1680.33 foot-pounds/second \pm 180.66 foot-pounds/second) to T_4 (1774.80 foot-pounds/second \pm 172.31 foot-pounds/second).
3. There was a significant decrease ($p \leq 0.05$) in percent of body fat from T_1 (20.22 percent \pm 3.63 percent) to T_4 (18.42 percent \pm 3.16 percent).
4. There were significant increases ($p \leq 0.05$) in all absolute strength measures; bench press T_1 (60.29 pounds \pm 12.05 pounds) to T_4 (86.47 pounds \pm 14.12 pounds), parallel squat T_1 , (82.94 pounds \pm 19.77 pounds) to T_4 (144.71 pounds) \pm 26.72 pounds), and deadlift T_1 (119.12 pounds \pm 13.72 pounds) to T_4 (165.88 pounds \pm 26.17 pounds).

Discussion

The primary purpose of this study was to investigate the anaerobic power gains in females as a result of an eight-week weight training program. Subjects included 16 untrained, college-aged female students at Appalachian State University. The weight training program was completed during the Spring Semester of 1982 in the Wey Free Weight Room.

The subjects encountered a one-week rest period between the fourth and fifth weeks of training. The one-week rest period may have had a influence on the results of the present study. The design of the present study was such that the eight-week lifting program emulated the same time restraints of athletes training during Spring Semester at Appalachian State University. Most colleges and universities encountered a break of this nature. A more complete analysis concerning the effects that the one-week rest period had on the power increases was included later in this discussion of the present study.

As previously stated, the primary purpose of the present study was to investigate anaerobic power gains in females. Power has appeared to be an important factor in activities that require energy supplied through the anaerobic energy system. The present study was directed at testing the physiological effects

of a weight training program (heavy resistance training) and the anaerobic increases that occurred as a result of the weight training program.

The secondary and tertiary purposes of the present study examined the changes that occurred in absolute strength and body composition as a result of the eight-week program. Increases in absolute strength and body composition have been documented in the existing literature (1, 4, 11, 13, 17, 18, 21, 22, 26, 28, 29). The findings of the present study revealed significant increases in the absolute strength measures of bench press, parallel squat, and deadlift. These significant increases in strength are consistent with the findings of other studies (11, 13, 17, 18, 21, 22, 26, 28, 29). Decreases in percent of body fat and increase in lean body mass were also revealed in the present study. These results were also consistent with previous findings.

The most important variable investigated in the present study was the increase that occurred in anaerobic power output. A study by O'Shea (21) in 1981, investigated power weight training and females. However, anaerobic power output was not discussed in that study. To the author's knowledge, not one study has investigated the anaerobic power gains in females as a result of power weight training.

The author of the present study designed an eight-week weight training program to elicit anaerobic power increases in females.

The studies discussed in the review of literature of the present study utilized strength training programs that were from five weeks in duration to the longest study that extended four and one-half months. The author utilized an eight-week program for two specific reasons. Most of the studies discussed in the review of literature in the present study were from 5 to 12 weeks in duration (1, 2, 3, 4, 11, 13, 17, 18, 20, 21, 22, 28). Secondly, the hypothetical model of strength training by Stone et al. (23) suggests a program from 6 to 10 weeks. (See Appendix B.) In the presentation and analysis of data of the present study, it appeared eight weeks was sufficient to elicit gains in absolute strength, body composition, and most importantly anaerobic power. (See Appendix C.)

A Tukey post hoc test was performed in the present study to determine the significant differences that occurred in anaerobic power among treatments. The Tukey value yielded significant differences between T_1 and T_2 , T_1 and T_3 , and T_1 and T_4 (See Table II.) A significant increase did not occur between T_2 and T_3 or between T_3 and T_4 . An increase was not expected between T_2 and T_3 because the one-week rest period occurred between the two testing sessions. However,

a significant decrease did not occur between T_2 and T_3 , leading the author to conclude the one week rest period did not have a negative effect on the present study.

Of primary interest was the fact that there was not a significant increase in power between T_3 and T_4 . According to Stone et al. (24), the greatest increase in power usually occurred during this phase of the periodization program. The modified version of periodization used in the present study did not include adequate volume throughout the entire eight-week training program, specifically during the hypertrophy phase, to elicit the desired increases in power.

In conclusion the author has focused on the primary scope of the present study. Untrained college-aged females were subjects in the eight-week weight training program. Significant increases occurred however, in absolute strength, body composition, and anaerobic power. The implications of a power oriented training program are broad. Athletes that have needed to improve performance in a power sport have apparently needed some type of power training. The author concluded that training for power is sufficient to elicit significant gains in anaerobic power and this may be included in the training regimen of a power sport athlete (6).

The author has further concluded that through a complete examination of the results of the present

study, significant increases can be acquired by females involved in training for power. As stated previously, the present protocol was a modified version of the periodization model (23, 24). Perhaps increases of a greater degree would have occurred, especially between T_3 and T_4 , if the training protocol had utilized periodization as described by Matyev (16) and Stone et al. (23, 24), rather than the modified version utilized in the present study.

Conclusions

Within the limits of the present study the following conclusions were:

1. The weight training protocol utilized in the present study was sufficient to realize significant increases in the absolute strength measures taken.
2. The weight training protocol utilized in the present study was sufficient to realize significant increases in lean body weight and decreases in percent of body fat.
3. The weight training protocol utilized in the present study was sufficient to realize significant increases in anaerobic power.

Recommendations

It is recommended that females be tested for anaerobic power gains as a result of weight training with a program closer to the guidelines of

periodization provided by Stone et al. (23, 24) than the program used in the present study. It is further recommended that multiple anaerobic power tests be used to evaluate changes due to treatment.

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APPENDICES

APPENDIX A

INDIVIDUAL FOLDER MATERIAL

PERFORMANCE DATA FORM

NAME				
AGE				
TEST #	1	2	3	4
Date of Test				
Weight				
Percent Body Fat				
Lean Body Weight				
Vertical Jump				
Anaerobic Power				
Bench Press (1RM)				
Squat (1RM)				
Deadlift (1RM)				

APPENDIX A (CONTINUED)

RAW DATA FORM

NAME						
TEST #						
Date of Test						
Weight						
Percent Body Fat	Trial #	1	2	Avg.	% fat	
	(illiac)	—	—	—	—	
	(tricep)	—	—	—	—	
Vertical Jump	Trial #	1	2	3	Avg.	
		—	—	—	—	
		Anaerobic Power				ft./lbs.
Bench Press (1RM)	-----					
Squat (1RM)	-----					
Deadlift (1RM)	-----					

APPENDIX A (CONTINUED)

SUBJECT CONSENT FORM

1. I, _____ (print name of subject), hereby authorize members of the Appalachian State University Department of H.P.E.R., and assistants selected by them, to administer to me the physical exercise and medical tests for analysis as described in the following procedure:

Each subject will complete a test session consisting of:

- (1) Vertical Jump
 - (2) One Repetition Maximum (Bench Press, Squat, Deadlift)
 - (3) Body Composition
2. I have been informed that maximal exercise may constitute a risk of harm to persons with medical or health problems. I certify that I am in good health and have no known medical or health problem causing me to limit my physical activities.
3. I have understood the explanation of the procedures and voluntarily agree to participate in this study, and I understand the following:

Each subject will need to be available to report to the Human Performance Laboratory for four sessions over a period of twelve weeks during the months of January through April. Subjects will be needed for a maximum of one hour per session, Monday through Friday.

Signature of Subject

Date of Consent

APPENDIX B

TRAINING PROTOCOL

Exercises

1. Squat
2. Bench Press
3. Deadlift
4. Hamstring Curl
5. Lat Pull
6. Shoulder Press
7. Biceps Curl
8. Triceps Press
9. Crunch Situps

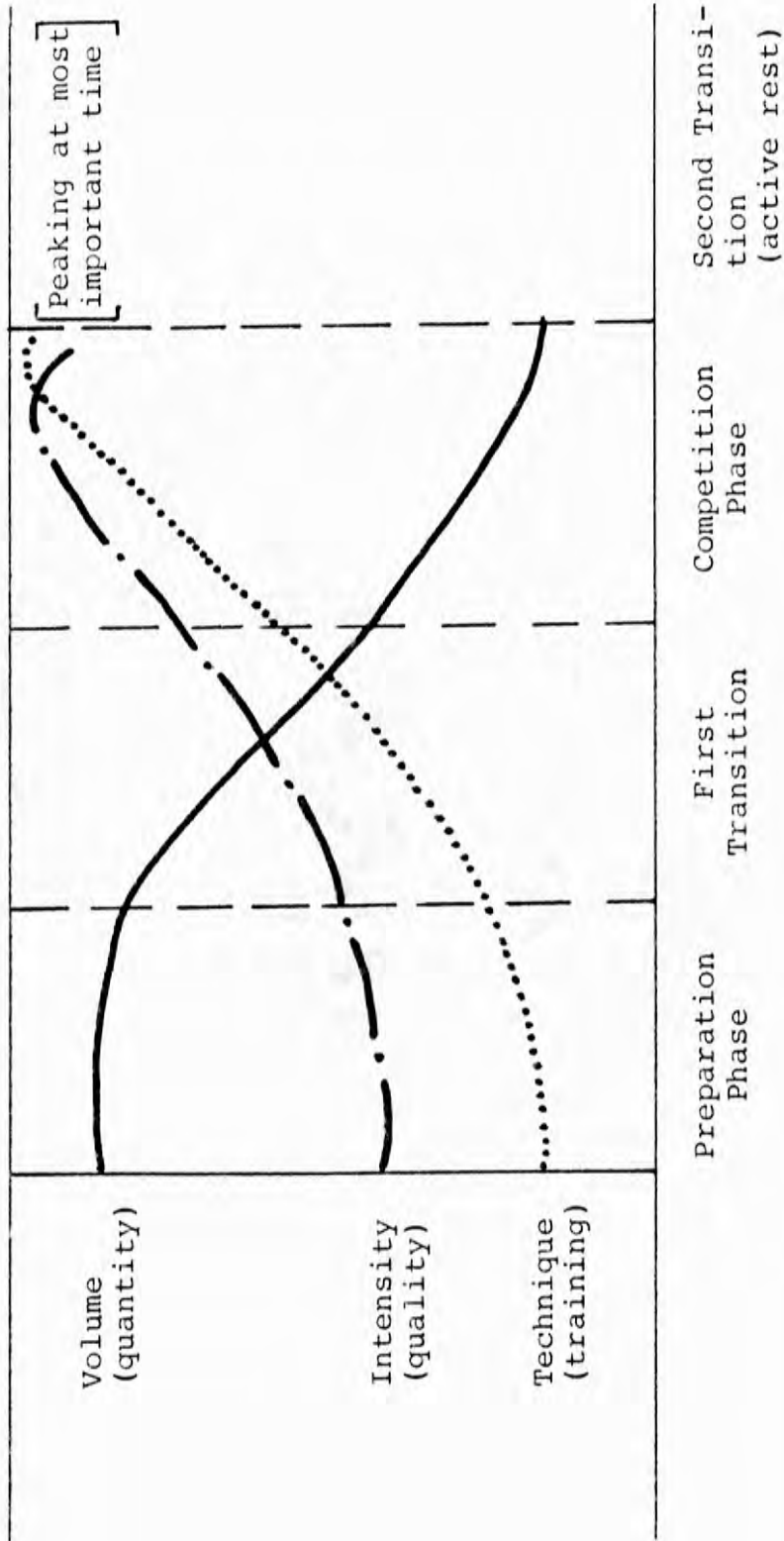
Eight-Week Power Lifting Model*

WEEK	1	2	3	4	5	6	7	8
Phase	Hyper-trophy Phase		Basic Strength Phase			Strength and Power Phase		Peaking or Maintenance
Sets/Repetitions	1/12		2/6			2/3		1/3
Intensity	low		high			high		very high
Volume	high		moderate to high			low		very low

* Adapted from Matveyev's Periodization Model. Matveyev, L.P. Periodisierung des sportlichen training (translated into German by P. Tschiene, revised with a chapter by A. Kruger), Berlin: Berles and Worintz, 1972 and Stone, Michael H., Harold O'Bryant, and John Garhamer. "A Hypothetical Model of Strength Training." The Journal of Sports Medicine and Physical Fitness, 21:342-351. December 1981.

APPENDIX B (CONTINUED)

Matveyev's Model of Periodization



APPENDIX B (CONTINUED)

Preparation → Transition → Competition → Transition 2 (Active Rest)

Phase	Hypertrophy	Basic Strength	Strength & Power	Peaking or Maintenance
Sets	3- 5	3- 5	3- 5	1- 3
Reps	8-20	2- 6	2- 3	1- 3
Days/Wk	3- 4	3- 5	4- 6	1- 5
Times/Day	1- 3	1- 3	1- 2	1
Intensity Cycle (weeks)	2-3/1	2-4/1	2-3/1	-
Intensity	low	high	high	very high to low
Volume	high	moderate to high	low	very low

Hypothetical Model of Strength Training
 (Associated with Matveyev's Periodization Model)

* Stone, Michael H., Harold O'Bryant, and John Garhamer. "A Hypothetical Model of Strength Training." The Journal of Sports Medicine and Physical Fitness, 21:342-351. December 1981.

APPENDIX C

PERFORMANCE DATA

Absolute Strength Values

TEST #	VARIABLE	MEAN	SD	RANGE
1	bench press	60.29 \pm	12.05 lb.	45- 95 lb.
1	squat	82.94 \pm	19.77 lb.	45-125 lb.
1	deadlift	119.12 \pm	13.72 lb.	85-125 lb.
4	bench press	86.47 \pm	14.12 lb.	65-125 lb.
4	squat	144.71 \pm	26.72 lb.	75-200 lb.
4	deadlift	165.88 \pm	26.17 lb.	125-225 lb.

Vertical Jump Values

TEST #	VARIABLE	MEAN	SD	RANGE
1	vertical jump	10.41 \pm	2.03 in.	6-13.3 in.
2	vertical jump	11.18 \pm	1.75 in.	8-13.3 in.
3	vertical jump	11.13 \pm	2.24 in.	7.7-15 in.
4	vertical jump	11.43 \pm	1.87 in.	8.7-14.2 in.

APPENDIX C (CONTINUED)

Anaerobic Power Values

TEST #	VARIABLE	MEAN	SD
1	anaerobic power	1680.33 \pm	180.60 ft.lbs/sec.
2	anaerobic power	1755.16 \pm	190.54 ft.lbs/sec.
3	anaerobic power	1740.87 \pm	204.69 ft.lbs/sec.
4	anaerobic power	1774.80 \pm	172.31 ft.lbs/sec.

Body Composition Values

TEST #	VARIABLE	MEAN	SD
1	percent body fat	20.22 \pm	3.63 percent fat
4	percent body fat	18.42 \pm	3.16 percent fat

APPENDIX D

PHYSICAL CHARACTERISTICS OF SUBJECTS

TEST #	VARIABLE	MEAN	SD	RANGE
1	age	19.29 \pm	1.35	18- 22 yrs.
1	weight	131.58 \pm	18.23	108-177 lbs.
2	weight	132.17 \pm	18.64	106-176 lbs.
3	weight	131.76 \pm	18.40	109-173 lbs.
4	weight	132.24 \pm	17.97	106-174 lbs.

APPENDIX E

Sloan Formula for Predicting Body Density in Females

$$\begin{aligned} \text{Body Density} &= 1.0764 - 0.00081 \\ &(\text{Suprailiac S.F.}) - 0.00088 (\text{tricep S.F.}) \\ \text{Fat} &= \left(\frac{4.570}{\text{density}} - 4.142 \right) 100 \end{aligned}$$

Sloan, A.W., and C.S. Blyth. "Estimation of Body Fat in Young Women." Journal of Applied Physiology, 17: 967-970, 1962.

APPENDIX F

Lewis Formula for Predicting Anaerobic Power

$$P = (4) \text{ (Body Weight) } (\sqrt{\text{Vertical Jump}}) =$$

foot-pounds/second

Mathews, Donald K. and Edward L. Fox, The Physiological Basis of Physical Education and Athletics. Philadelphia: W. B. Saunders Company, 1976.

VITA

David Alan Ward was born in Charlotte, North Carolina, on November 3, 1955. He attended the Charlotte-Mecklenburg Schools until he graduated from Olympic High School in June, 1974. The following year he enrolled at Appalachian State University where he received a Bachelor of Science Degree at Appalachian State University in May, 1979.

After two years of full-time decathlon training, he accepted a teaching assistantship at Appalachian State University in September, 1981. At the completion of assistantship, Mr. Ward accepted a teaching position at Charlotte Latin School in August, 1982. He has been working on his degree during summer and vacations.

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