BENCH STEPPING AND RESISTANCE TRAINING
A COMPARISON OF STRENGTH GAINS IN
TRAINED HIGH SCHOOL FEMALE
DISTANCE RUNNERS

by

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Bachelor of Arts

Oklahoma Baptist University

Shawnee, Oklahoma

1981

Submitted to the Faculty of the
Graduate College of
Oklahoma State University
in partial fulfillment of
the requirements for
the degree of
MASTER OF SCIENCE
July, 1993

OKLAHOMA STATE UNIVERSITY

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Thesis Approved:

Thesis Adviser

Dean of the Graduate College

ACKNOWLEDGEMENTS

I owe much to several people who have been instrumental in my pursuance of a masters degree in the past five years. First, I must thank Dr. Frank Kulling, who from my first day at OSU, cultivated in me a keen interest in the exercise sciences.

Secondly, I thank Dr. Betty Edgley, whose door and council was always available to me regardless as to how inconvenient it was for her.

Thirdly, I would like to thank Dr. Bert Jacobson for developing in me an interest and desire to pursue a career in research.

I also would like to thank Dr. Steven Edwards for his help with the statistical work and spurring an interest within me in this area.

Also a special thanks to Skip Stevens, C.P.T. for all of his help in pretesting and posttesting.

Finally, and most of all, I thank my wife and my parents for the support and encouragement through all of the time that I spent in my studies.

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CHAPTER I

INTRODUCTION

It is well established that modes of exercise such as running (6,12,25,28) and aerobic dance (46) elicit a chronic training adaptation of improved maximum oxygen uptake (VO2 Max). More recently, stairclimbing and bench stepping have enjoyed increased popularity and have joined the more traditional and established exercises as accepted modes of exercise for the development of cardiovascular functional capacity. Yet while bench stepping and stairclimbing are the most current and popular trends in fitness training, few studies exist investigating these modes of exercise with respect to chronic training adaptations in any physiological parameter other than cardiovascular.

Bench stepping, and the subsequent heart rate recovery, has been utilized for decades as a reliable and valid field test for estimating cardiovascular fitness (2,3,8,9,17,24, 27,30,32,37,45). Stairclimbing has correlated well with the Balke treadmill test and bicycle ergometry in cardiovascular physiological responses (19,20,38). The American College of Sports Medicine (ACSM) has established a metabolic formula for estimating the volume of oxygen consumed during bench stepping (1). Stairclimbing has been associated with a decrease in episodes of and mortality from coronary heart disease (14,35,40). Studies have demonstrated significant improvement in cardiovascular physiological measures following a stairclimbing or bench stepping program (4,44). Bench stepping has also been observed to elicit a somewhat lower blood lactate concentration level for a given relative exercise intensity than running or cycling (43).

While it is clearly established from the literature that there is a cardiovascular training effect from bench stepping and stairclimbing, no research has investigated the strength gains that may occur.

Purpose of the Study

The purpose of this study is to determine if bench stepping will elicit significant improvements in strength in the hip extensors,knee extensors, and ankle plantar flexors in trained female teenage distance runners while simultaneously participating in the pre-season preparation phase of a competitive cross-country season and to determine if those gains are comparable to the improvements in strength derived from traditional resistance training.

Extent of the Study

Delimitations

This study was delimited to:

1. A sample of eight junior high and high school

female subjects selected from a girls cross-country team.

2. Student athletes participating in competitive cross country with parental consent.

3. The measurement of strength in the hip extensors, knee extensors, and ankle plantar flexors at angular velocities of 30, 180, and 300 degrees per second.

4. Subjects were a convenience sample.

5. Starting loads were selected in accordance to the subject's ability to perform 15 repetitions comfortably.

Limitations

The results of this study may have been limited by the following:

1. The limited number of subjects (8).

2. The resistance training group was unfamiliar with weight lifting.

3. Strength gains (anabolic affects) may be affected by the simultaneous participation of the subjects in distance running (catabolic affects).

Assumptions

The following assumptions were made:

1. It was assumed all subjects complied with the treatment schedule.

2. It was assumed that subjects exerted maximum effort on both pretest and posttest.

3. Subjects performed no additional strength developing

exercises during the course of the study.

4. Subjects maintained proper cadence (steps per minute) during bench stepping.

5. Subjects increased loads as their ability allowed.

Hypotheses

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

1. There will be no significant difference in mean pretest and posttest isokinetic strength scores in the resistance training group.

2. There will be no significant difference in mean pretest and posttest isokinetic strength scores in the bench stepping group.

3. There will be no significant difference between the two research groups in mean posttesting isokinetic strength scores.

Conceptual Definitions

Isokinetic. A muscular contraction performed at constant angular limb velocity. (13)

Isokinetic Strength. The maximum amount of force that a muscle or muscle group can exert at a constant angular limb velocity. (13)

Anabolic Effects. All chemical changes by which the absorbed products of digestion are used to replace substances broken down during life processes and to build new tissues in growth. (5)

Catabolic Effects. Processes by which nutrients, reserve tissue material, and cellular substances are broken down into simpler compounds resulting in the liberation of energy. (5)

Functional Definitions

Loads. The amount of resistance used during an exercise.

Repetition. The number of times an exercise is performed in a set.

Set. A group of repetitions followed by rest.

1 Repetition Max. The maximum amount of weight lifted for 1 repetition.

CHAPTER II

REVIEW OF THE LITERATURE

Bench Stepping as an Indicator of Fitness

The evolution of bench stepping from a field test for cardiovascular fitness to a popular mode of fitness training dates back to World War II. A need arose for a quick and practical means to field test large masses of men in the military to provide a basis whereby combat officers could be selected. Gallagher and Brouha (17) devised a simple test involving the stepping up and down on an 18 or 20 inch platform at 30 steps per minute for 5 minutes. Immediately following the cessation of the 5 minute exercise interval, a recovery pulse would be taken at predetermined intervals. Based on the subject's resting pulse (taken prior to the test), a fitness score was derived from how well the subject's heart rate recovered from the bout of exercise. This test, now known as the Harvard step test, became a standard for medical professionals, fitness educators, and coaches to quickly evaluate large groups of patients, students, and athletes without costly or impractical equipment.

In subsequent years, researchers investigated the validity of the Harvard step test with more precise and objective measures of cardiovascular fitness. Astrand and Ryhming (2) developed a nomogram for the calculation of maximum aerobic capacity (VO2 Max) from the pulse rate of submaximal exercise. This nomogram was based on research using heart rate measures from treadmill, cycle ergometry, and bench stepping. Bench stepping demonstrated similar linear heart rate increases as did treadmill or cycle ergometry testing for submaximal exertion.

Questions concerning subject's anthropometric variables that may invalidate the step test scores arose in the 1950's. Keen and Sloan (27) determined that fitness index results from the Harvard step test were not significantly correlated with bodyweight, leg length, total body height, or bi-iliac diameter, but were highly correlated (-0.36 ratio , $P<0.01$) with resting heart rate.

In 1965, Nagle et al. (37) developed a variation of the Harvard step test. A device was constructed allowing the height of the stepping platform to increase in elevation from 2.0 to 50.0 centimeters as the subject continued to step at a prescribed cadence. From this study an equation calculating the metabolic costs of bench stepping at varying heights and speeds was derived. The ACSM presently uses this formula (1) in calculating oxygen consumption and caloric expenditure.

Further validation and variation development of bench stepping by researchers occurred in the 1960's and 1970's.

A test was constructed in 1969 (30), later referred to as the Ohio State step test (OSU), to develop a situation whereby a greater range of subjects (age, physical condition) could be tested. Many subjects, for a variety of reasons, were unable to complete the Harvard step test. The OSU step test, rather than setting a time limit (5 minutes) to finish the test established a heart rate of 150 beats per minute by the subject as the test termination criterion. Phase I of the OSU test consists of 6 innings at 24 steps/ minute on a 15 inch bench. Phase II consists of 6 innings at 30 steps/ minute on a 15 inch bench. Phase III consists of 6 innings at 30 steps/ minute on a 20 inch bench. Each inning is 50 seconds in duration, divided into a 30 second work period and a 20 second rest period. A 10 second pulse check at the beginning of the 20 second rest period determines if the subject continues to the next inning. The test is terminated when the subject's pulse reaches 150 beats per minute. A test-retest reliability coefficient of .94 was obtained for the OSU step test. The OSU test results also correlated with the Balke Treadmill Test with a validity coefficient of .94.

In 1971, the adjustable step test developed by Nagle (37), was determined to yield no significant difference ($P > 0.05$) in heart rate response than either bicycle ergometry or the Balke Treadmill Test (36). Also in 1971, a modified OSU step test was developed (9) using a 17 inch bench throughout the test rather than the originally prescribed 18 and 20 inch benches. A test-retest reliability of .94 and a correlation of .94 with the Balke Treadmill Test were determined.

In 1972, a three minute step test for college women was developed (32) utilizing a 16.25 inch bench and stepping to a cadence of 22 steps/minute. A validity correlation of (r-.75) was obtained between VO2 Max from the Balke Treadmill Test and the 5 to 20 second recovery heart rate from the 3 minute step test.

In 1973, further modifications to the OSU step test were developed to accomodate the higher resting heart rates of female subjects (49). Bench heights of 14 and 17 inches were employed with a maximum of 20 innings, rather than the original 18 innings. An exercise heart rate of 168 beats per minute by subjects was established as the criterion for test cessation. A test-retest reliability coefficient of .90 was obtained and a validity coefficient of .85 was reported with the Balke Treadmill Test.

Shapiro et. al. (45) constructed a very simple step test for the mass testing of high school subjects. Several bench heights were studied to determine the optimum height for high school age students in the 6 minute test. It was concluded that 32.5 centimeters best correlated with bicycle ergometry (r=0.809).

Indian researchers, in 1983, found the Harvard step test to be invalid when used as a measure of cardiovascular fitness in adolescent populations with a bodyweight of

<45 kilograms. The researchers suggested a modified score interpretation for subjects <45 kilograms when utilizing a 20 inch bench as prescribed by the Harvard step test.

While the utilization of bench stepping by the early 1980's was still viewed as a diagnostic tool for fitness, a parallel trend beginning in the 1950's with staircimbing eventually merged with bench stepping by the 1980's, culminating in the mass popularity of bench aerobics as a viable alternative to other modes of fitness training.

Evolution of Stairclimbing as a Mode of Fitness

In 1953, a study was published reporting the episodes of coronary heart disease in men working for the London Transport System (35). The study involved 31,000 employees with ages ranging from 35 to 64. The major finding from this study revealed that, as a group, conductors experienced far fewer episodes of coronary heart disease than the subway drivers. The study suggested as a possible explanation for this phenomenon the protective factor of exercise (primarily ascending and descending stairs). Although the stairclimbing was not deliberately undertaken by the conductors for the express purpose of augmenting cardiovascular fitness, the benefits were statistically significant. A 1975 study also showed a significant improvement in maximum aerobic power in 30 healthy male subjects when participating in an at work stairclimbing intervention program (14).

Stairclimbing and cycling were compared in a 1979 study (38) as to acute pulmonary and circulatory responses. The heart rate and VO2 responses of the two exercises were found not to be significantly different, but VCO2 and post exercise lactate levels were lower in the stair climbing group.

By the mid-1980's, the stairclimbing apparatus had found widespread popularity in many fitness and health clubs. This precipitated a surge of research to examine the possible cardiovascular benefits to be derived from a stairclimbing program. Twelve male firefighters were examined before and after a 10 week training program on the model 5000 Stairmaster for changes in VO2 Max. A mean improvement of VO2 Max from 41.4ml/kg/min to 51.0ml/kg/min was reported (4). A similar study (44) using female subjects also reported significant gains in VO2 Max (36%) from a 12 week program on the Stairmaster.

The late 1980's marked the initiation of research on stairclimbing with cardiac rehabilitation patients. No significant differences were found when comparing treadmill and stairclimbing physiological responses in cardiac patients (48). It was concluded that stairclimbing was a safe alternative to treadmill walking for cardiac rehabilitation patients. Similar results were published a year later in 1988 by Holland et. al. for cardiac patients (20) and also for young healthy populations (19).

Although a plethora of evidence supporting stairclimbing and bench stepping as efficacious modalities for improving cardiovascular fitness, there has been no record to date of research inquiry into the potential for musculo-skeletal adaptations.

Resistance Training for Distance Runners

While volumes of research investigating the training effects of various resistance training protocols on a variety of athletes, no literature exists documenting firm statistically significant evidence of an optimum lifting protocol specifically for distance runners. The traditional approach of utilizing a high repetition exercise prescription for distance runners is based upon anecdotal evidence. The common rationale for distance runners including resistance exercises into their training is primarily for injury prevention purposes and not for strength enhancement (16). Several studies do demonstrate a compromise in strength augmentation for endurance runners engaged in resistance or power training (11,18,39), but fail to make recommendations as to an appropriate set/rep/rest protocol based upon empirical evidence. At present, the common practice for endurance runners is to employ a high repetition/light weight/short rest period protocol (16).

CHAPTER III

PROCEDURES

Introduction

The procedures in this chapter will be divided into two sections; preliminary and operational. Preliminary procedures involve the selection of subjects, obtaining consent, selection of dependent variables, and selection and employment of a measuring device. The operational procedures include instructions to subjects, collection of data, treatment procedures, and analysis of the data.

Preliminary Procedures

Selection of subjects

The subjects were 8 volunteers from a girls cross country team. Originally 10 subjects were to participate in the study and were randomly divided evenly into 2 groups. Subjects served as their own control. Due to attrition during the course of the study, 3 subjects were in the WTR group and 5 subjects were in the BSR group. Of the two subjects not completing the study, one was hospitalized due to an intestinal obstruction and the second underwent knee surgery for medical causes unrelated to the treatment.

The researcher, also the coach, monitored and supervised all aspects of the study. Subjects' data is detailed in Table I.

TABLE I

SUBJECT'S DESCRIPTIVE DATA

Subject	Age	Weight (lbs)	Height (in)	Pretest BFat%	Posttest BFat%
1	15	93	57	28.1	25.8
2	15	122	67	24.2	24.9
3	14	110	65	23.0	21.7
4	15	112	63	27.5	27.4
5	13	90	60	27.7	25.2
6	16	120	65	24.3	21.5
7	13	100	62	22.3	20.2
8	14	101	63	19.5	17.3

Obtaining consent

Permission to conduct the study was obtained from the Oklahoma State University Institutional Review Board (OSU IRB) and from the parents of the subjects (see Appendices A and B). Individual consent forms were signed prior to the beginning of the study.

<u>Selecting a dependent variables</u>

Three angular velocities were chosen to measure any significant differences in torque. Subjects were tested at 30, 180, and 300 degrees per second for ankle, knee and hip flexion and extension. Studies have demonstrated (10,26) that strength adaptations are specific to the training velocity implemented. Resistance training involves slow to moderate angular limb velocities, while unloaded bench stepping at 24 to 30 steps per minute require muscular contractions at much faster (over 180 degrees per second) angular limb velocities. Research studies involving isokinetic strength testing have utilized various angular velocities. Thirty, 180, and 300 degrees per second were the angular velocities chosen for this study in order to detect any velocity specific strength gains resulting from the wide range of angular velocities used in the treatments.

A second consideration was the choice of joint actions. Hip and knee extention are common to both bench stepping and squatting, so both actions were included in the study. Anecdotal evidence derived from the researcher's experience with bench stepping indicates a significant contribution of the plantar flexors. For this reason, ankle plantar flexion was included in the study along with hip and knee extension.

<u>Equipment</u>

Pretesting and posttesting was conducted on a LIDO

Active Isokinetic System (Loredan, Inc., Davis, California). The LIDO was made available by the local hospital's physical therapy department. This system has demonstrated to be valid and reliable in the measurement of isokinetic strength (41).

Bench stepping was conducted on wooden benches, 30.48 centimeters high, constructed by the high school's maintenance department. The resistance training group performed all training on standard olympic free weights, dumbells, a Bodysmith Glute-Ham Developer, and a Bodysmith lat machine.

Operational Procedures

Pretest instructions

Subjects were instructed to refrain from any physical exertion on the day prior to and the day of the pretesting. Subjects were also instructed to wear exercise clothing. All subjects received instruction on the correct form in the performance of each isokinetic movement. Each subject was allowed to warm-up by stretching and performing submaximal efforts on the isokinetic machine to familiarize themselves with each test. Measurements for each subject were taken and recorded from the greater trochanter at the hip joint to the LIDO attachment at the knee and the lateral femoral epicondyle at the knee to the LIDO attachment at the ankle. This was done to insure consistant measurements from the point of force application (LIDO knee or ankle attachment) to the axis of rotation from pretesting to posttesting. Subjects were instructed to exert maximal effort on each repetition. Subjects were told how many repetitions they would be performing before each test but were instructed to continue until verbally told to stop by the researchers. After the initiation of each test, each subject was verbally encouraged to continue and give maximal effort throughout the the duration until the test was terminated by the researcher. Each subject underwent a total of 18 isokinetic measurements and was given specific rest intervals between each one. Table 1 gives the order of tests, the number of repetitions on each test, and the rest intervals between each test.

TABLE II

ISOKINETIC PRETEST AND POSTTEST SCHEDULE

FOR BOTH TREATMENT GROUPS

1. Left knee	30 degrees/sec	X 3 reps	3 minutes rest
2. Left knee	180 degrees/sec	X 3 reps	3 minutes rest
3. Left knee	300 degrees/sec	X 15 reps	20 minutes rest
4. Right knee	30 degrees/sec	X 3 reps	3 minutes rest
5. Right knee	180 degrees/sec	X 3 reps	3 minutes rest
6. Right knee	300 degrees/sec	X 15 reps	20 minutes rest
7. Left ankle	30 degrees/sec	X 3 reps	3 minutes rest
8. Left ankle	180 degrees/sec	X 3 reps	3 minutes rest
9. Left ankle	300 degrees/sec	X 15 reps	20 minutes rest
10. Right ankle	30 degrees/sec	X 3 reps	3 minutes rest
11. Right ankle	180 degrees/sec	X 3 reps	3 minutes rest
12. Right ankle	300 degrees/sec	X 15 reps	20 minutes rest
13. Left hip	30 degrees/sec	X 3 reps	3 minutes rest
14. Left hip	180 degrees/sec	X 3 reps	3 minutes rest
15. Left hip	300 degrees/sec	X 15 reps	20 minutes rest
16. Right hip	30 degrees/sec	X 3 reps	3 minutes rest
17. Right hip	180 degrees/sec	X 3 reps	3 minutes rest
18. Right hip	300 degrees/sec	X 15 reps	finish

<u>Pretreatment instructions</u>

All subjects were given their group assignments, a written schedule of their 8 week treatment, and a time schedule for all workouts. (See Tables III, IV, and V).

<u>Treatment group instructions</u>

After being informed of their group assignments and given their 8 week treatment schedule, all subjects received instruction on the correct technique for performing all resistance exercises and bench stepping. The instruction and supervision of the orientation sessions for the subjects was conducted by a Certified Strength & Conditioning Specialist. Each subject practiced each exercise in the treatment program until correct and safe technique could be demonstrated. In addition, subjects were provided weight room safety instruction. Appendices C, D, and E contain the general instructions on correct technique for the resistance exercises used, instructions for bench stepping, and instructions on weight room safety respectively.

Data collection

Data from the pretest and posttest were automatically stored and later retrieved on a computer readout by the LIDO Isokinetic System. Two measururements were automatically recorded by the LIDO System; peak torque and average peak torque. Raw scores were recorded to the first decimal. Protocal for the posttest was identical to the pretest.

Training

Upon completion of the pretesting, subjects met 4 days per week (Monday-Thursday) at 10:30 A.M. Both groups ran their assigned distance prior to either lifting or stepping. Loads and progression were recorded on a daily log book by each subject.

Weight training group procedure

The resistance training treatment group lifted on a 4 days on / 3 days off (22) schedule. The lower extremities were trained Mondays and Wednesdays, while the upper extremities were worked on Tuesdays and Thursdays. Resistance training was conducted subsequent to the distance running. Since the subjects involved were novice to resistance training, inititial loads were not determined by a percentage of a 1 repetition maximum lift. It was deemed by the investigator that 1 repetition maximum lifts in subjects untrained in weight lifting would risk the safety of the subjects due to an insufficient foundation of the musculoskeletal structure. Starting loads on all lifts were determined prior to the initiation of the treatment in accordance to each subject's ability to safely perform 15 repetitions with correct technique. Repetitions were held in the 10 to 15 range (16) to approximate the traditional cross country resistance training protocol. Progression of the loads each week were determined by each subject's ability to safely perform the previous week's prescribed number of repetitions and sets. All three sets of an exercise were completed before progressing to the next exercise. Table III presents the 8 week resistance training program. Appendix C presents a list of each resistance exercise and the correct technique to be followed for each.

TABLE III

EIGHT WEEK RESISTANCE TRAINING PROGRAM

Monday/Wednesday

Exercise	Weeks 1-3	Weeks 4-6	Weeks 7-8
Half squats	3 X 15	3 X 12	3 X 10
Dead lifts	3 X 15	3 X 12	3 X 10
Glute-ham-developer	3 X 6	3 X 8	3 X 10
Hyperextensions	3 X 10	3 X 12	3 X 15
Hip flexor	3 X 15	3 X 12	3 X 10
Crunches*	10 reps	12 reps	15 reps

* to be done at the completion of every third set

Tuesday/ Thursday

Exercise	Weeks 1-3	Weeks 4-6	Weeks 7-8
Bench press	3 X 15	3 X 12	3 X 10
Push press	3 X 15	3 X 12	3 X 10
Lat pulldowns	3 X 15	3 X 12	3 X 10
Pullovers	3 X 15	3 X 12	3 X 10
DB front raises	3 X 15	3 X 12	3 X 10
Hammer curls	3 X 15	3 X 12	3 X 10

Bench stepping group procedure

The bench stepping treatment group trained 4 days per week (Monday-Thursday) at 10:30 A.M. Subjects in the bench stepping group ran their assigned distance prior to proceding with stepping. All subjects stepped on a wooden bench 30.48 centimeters high at a starting cadence of 24 steps per minute, progressing over the 8 weeks to 30 steps per minute. Duration of the bench stepping also progressed from 15 minutes the first week to 40 minutes the final week. Cadence was maintained by subjects stepping to the beat of prerecorded music. Music was selected to maintain the prescribed frequency for a given week. Subjects were continually monitored to insure that the prescribed cadence was maintained. Tables IV and V exhibit the 8 week bench stepping program and the running mileage for both treatment groups respectively.

TABLE IV

EIGHT WEEK BENCH STEPPING PROGRAM

Week #	Minutes Duration	Steps per Minute	Frequency per Week
1	15	24	4
2	20	24	4
3	25	24	4
4	30	24	4
5	25	30	4
6	30	30	4
7	35	30	4
8	40	30	4

TABLE V

EIGHT WEEK DISTANCE RUNNING SCHEDULE

Week	1	2	3	4	5	6	7	8
Miles	18	19	20	21	22	23	24	25

Control group procedures

Subjects from both treatment groups acted as their own controls.

Statistical Analysis

The differences between the two groups' pretest and posttest means were examined by a two-way repeated measures MANOVA: training groups x time. The dependent variables were:

1. Peak torque in hip extension, knee extension, and plantar flexion of the right leg at angular velocities of 30, 180, and 300 degrees per second.

2. Average torque in hip extension, knee extension, and plantar flexion of the right leg at angular velocities of 30, 180, and 300 degrees per second.

The data was analysed as follows:

1. The comparison of pretest and posttest peak torque and average torque means within the weight training group.

2. The comparison of pretest and posttest peak torque

and average torque means within the bench stepping group.

3. The comparison of the posttest peak torque and average torque means of the weight training group and the bench stepping group.

The Newman-Keuls Multiple Range Test was used as a post hoc mean comparison test. The level of significance was set at 0.05. Statistical computations were completed on the Oklahoma State University mainframe utilizing an SPSS statistical analysis package.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The purpose of this study was to determine the effects of bench stepping on strength gains in trained female high school distance runners and to compare those strength gains with the improvement in strength as a result of a more traditional resistance program. A two-way repeated measures MANOVA was used to analyse the data. The Newman-Keuls Multiple Range Test was used in all post hoc comparisons. The alpha level was set at .05.

Hypotheses Testing and Analysis

Three hypotheses were tested in this research study. The following is an evaluation of the results. Normative data are presented in Tables VI and VII.

First hypothesis

There will be no significant differences in mean pretest and posttest isokinetic strength scores in the resistance training group. Subjects in the resistance training group not only failed to significantly improve peak torque and average torque in the three different joint movements at the selected three angular velocities, but actually lost strength. These decreases in peak and average torque seemed to occur primarily in the slower velocities (30 degrees per second). The data provides a basis for accepting the first hypothesis.

Second hypothesis

There will be no significant difference in mean pretest and posttest isokinetic strength scores in the bench stepping group. Subjects in the bench stepping group failed to significantly improve peak and average torque in the three joint movements at the three selected angular velocities. The data provides a basis for accepting the second hypothesis.

Third hypothesis

There will be no significant difference between the two research groups in mean posttesting isokinetic strength scores. Analysis of the data through a 2-way repeated measures MANOVA indicated no significant differences between posttest peak or average torque means in the resistance training group and the bench stepping group at any of the angular velocities for the three joint movements. The data provides a basis for accepting the third hypothesis.

TABLE VI

MEANS AND STANDARD DEVIATIONS
FOR RESISTANCE TRAINING
GROUPS

Test (n=3)	Pretest mean(ft-lb)	S.D.	Posttest mean(ft-lb)	S.D.
RA 30 PT	x = 52.00	± 3.00	x = 38.33	± 4.93
RA 30 AT	x = 43.00	± 10.44	x = 35.33	± 7.02
RA 180 PT	x = 26.66	± 7.76	x = 29.66	± 5.50
RA 180 AT	x = 24.00	± 3.78	x = 28.33	± 6.02
RA 300 PT	x = 29.33	± 7.02	x = 30.66	± 4.04
RA 300 AT	x = 23.00	± 6.24	x = 28.00	± 4.58
RK 30 PT	x = 107.66	± 33.60	x = 96.66	± 9.29
RK 30 AT	x = 100.66	± 28.72	x = 91.33	± 8.32
RK 180 PT	x = 65.33	± 13.20	x = 69.66	± 8.32
RK 180 AT	x = 61.66	± 13.65	x = 67.00	± 9.53
RK 300 PT	x = 55.00	± 6.24	x = 58.00	± 7.93
RK 300 AP	x = 51.00	± 4.46	x = 52.33	± 5.50
RH 30 PT	x = 147.00	± 33.60	x = 131.00	± 33.94
RH 30 AT	x = 129.66	± 21.50	x = 120.50	± 43.13
RH 180 PT	x = 97.00	± 31.19	x = 93.00	± 22.06
RH 180 AT	x = 89.00	± 33.51	x = 89.00	± 23.06
RH 300 PT	x = 91.33	± 14.01	x = 86.00	± 4.35
RH 300 AP	x = 80.33	± 12.58	x = 76.33	± 5.03
BW	x = 107.00	± 11.26	x = 107.00	± 11.26
BF	x = 22.10	± 2.42	x = 19.66	± 2.15
AGE	x = 14.33	± 1.52		

RA - Right ankle RK - Right knee RH - Right hip
BW - Bodyweight BF - Bodyfat
PT - Peak Torque AT - Average Torque
30 - 30 degrees per second
180 - 180 degrees per second
300 - 300 degrees per second

All figures in foot-pounds

TABLE VII

MEANS AND STANDARD DEVIATIONS
FOR BENCH STEPPING
GROUP

Test (n=5)	Pretest mean(ft-lb)	Pretest S.D.	Posttest mean(ft-lb)	Posttest S.D.
RA 30 PT	x = 47.40	± 14.87	x = 49.40	± 13.01
RA 30 AT	x = 45.00	± 15.36	x = 47.00	± 13.26
RA 180 PT	x = 28.80	± 9.98	x = 34.40	± 7.57
RA 180 AT	x = 27.00	± 10.00	x = 32.40	± 7.30
RA 300 PT	x = 30.20	± 11.73	x = 34.00	± 6.24
RA 300 AT	x = 24.80	± 7.66	x = 28.80	± 5.89
RK 30 PT	x = 105.20	± 11.69	x = 105.2	± 21.66
RK 30 AT	x = 101.20	± 12.63	x = 101.20	± 20.71
RK 180 PT	x = 57.4	± 14.53	x = 65.80	± 8.70
RK 180 AT	x = 54.00	± 16.38	x = 63.80	± 8.43
RK 300 PT	x = 54.60	± 9.71	x = 56.80	± 7.01
RK 300 AT	x = 47.20	± 8.92	x = 49.00	± 5.65
RH 30 PT	x = 129.60	± 34.96	x = 126.20	± 33.25
RH 30 AT	x = 123.40	± 36.52	x = 122.60	± 32.93
RH 180 PT	x = 90.40	± 30.90	x = 91.00	± 18.80
RH 180 AT	x = 85.20	± 30.99	x = 85.40	± 20.72
RH 300 PT	x = 91.00	± 35.92	x = 86.80	± 16.96
RH 300 AP	x = 78.80	± 30.74	x = 76.00	± 15.28
BW	x = 105.6	± 13.64	x = 105.00	± 14.56
BF	x = 26.22	± 2.60	x = 25.00	± 2.08
AGE	x = 14.40	± .89		

RA - Right ankle RK - Right knee RH - Right hip
BW - Bodyweight BF - Bodyfat
PT - Peak Torque AT - Average Torque
30 - 30 degrees per second
180 - 180 degrees per second
300 - 300 degrees per second

All figures in foot-pounds

TABLE VIII

REPEATED MEASURES MANOVA
SUMMARY

Source	SS	df	MS	F
Between Groups (RK 30 PT)				
Group	34.50	1	34.50	.788
Within cells	2620.93	6	436.82	
Within Groups (RK 30 PT)				
RKnee (time)	113.44	1	113.44	.601
Group x RKnee	113.44	1	113.44	.601
Within cells	2234.00	6	372.33	
Between Groups (RK 30 AT)				
Group	101.40	1	101.40	.651
Within cells	2690.60	6	448.43	
Within Groups (RK 30 AT)				
RKnee (time)	81.67	1	81.67	.583
Group x RKnee	81.67	1	81.67	.583
Within cells	1454.33	6	242.39	
Between Groups (RKnee 180 PT)				
Group	110.70	1	110.70	.546
Within cells	1622.73	6	270.46	
Within Groups (RKnee 180 PT)				
RKnee (time)	214.70	1	214.70	.080
Group x RKnee	18.70	1	18.70	.557
Within cells	290.73	6	48.46	
Between Groups (RKnee 180 AT)				
Group	110.70	1	110.70	.546
Within cells	1622.73	6	270.46	
Within Groups (RKnee 180 AT)				
RKnee (time)	214.70	1	214.70	.085
Group x RKnee	18.70	1	18.70	.557
Within cells	290.73	6	48.46	

TABLE VIII (continued)

Source	SS	df	MS	F
Between Groups (RKnee 300 PT)				
Group	2.40	1	2.40	.890
Within cells	443.73	6	73.96	
Within Groups (RKnee 300 PT)				
RKnee (time)	25.35	1	25.35	.245
Group x RKnee	.60	1	.60	.849
Within cells	91.40	6	15.23	
Between Groups (RKnee 300 AT)				
Group	47.70	1	47.70	.453
Within cells	443.73	6	73.96	
Within Groups (RKnee 300 AT)				
RKnee (time)	9.20	1	9.20	.497
Group x RKnee	.20	1	9.20	.918
Within cells	105.73	6	17.62	
Between Groups (RAnkle 30 PT)				
Group	39.20	1	39.20	.715
Within cells	1599.73	6	266.62	
Within Groups (RAnkle 30 PT)				
RAnkle (time)	127.60	1	127.60	.002**
Group x RAnkle	230.10	1	230.10	.000**
Within cells	29.33	6	4.89	
Between Groups (RAnkle 30 AT)				
Group	175.10	1	175.10	.487
Within cells	1912.33	6	318.72	
Within Groups (RAnkle 30 AT)				
RAnkle (time)	30.10	1	30.10	.113
Group x RAnkle	87.60	1	87.60	.019**
Within cells	52.33	6	8.72	

TABLE VIII (continued)

Source	SS	df	MS	F
Between Groups (RAnkle 180 PT)				
Group	44.20	1	44.20	.568
Within cells	728.73	6	121.46	
Within Groups (RAnkle 180 PT)				
RAnkle (time)	69.34	1	69.34	.064
Group x RAnkle	6.34	1	6.34	.518
Within cells	80.60	6	13.43	
Between Groups (RAnkle 180 AT)				
Group	46.82	1	46.82	.549
Within cells	695.93	6	115.99	
Within Groups (RAnkle 180 AT)				
RAnkle (time)	88.82	1	88.82	.038**
Group x RAnkle	1.07	1	1.07	.781
Within cells	75.93	6	12.66	
Between Groups (RAnkle 300 PT)				
Group	16.54	1	16.54	.690
Within Groups	566.40	6	94.40	
Within Groups (RAnkle 300 PT)				
RAnkle (time)	24.70	1	24.70	.488
Group x RAnkle	5.70	1	5.70	.735
Within cells	271.73	6	45.29	
Between Groups (RAnkle 300 AT)				
Group	6.34	1	6.34	.758
Within cells	364.60	6	60.77	
Within Groups (RAnkle 300 AT)				
RAnkle (time)	75.94	1	75.94	.109
Group x RAnkle	.94	1	.94	.841
Within cells	129.00	6	21.50	

TABLE VIII (continued)

Source	SS	df	MS	F
Between Groups (RHip 30PT)				
Group	471.78	1	471.78	.667
Within cells	11326.65	5	2265.33	
Within Groups (RHip 30PT)				
RHip (time)	374.58	1	374.58	.017**
Group x RHip	185.15	1	185.58	.055**
Within cells	149.85	5	29.97	
Between Groups (RHip 30AT)				
Group	11.43	1	11.43	.948
Within cells	12140.00	5	2428.00	
Within Groups (RHip 30AT)				
RHip (time)	68.60	1	68.60	.348
Group x RHip	48.03	1	48.03	.426
Within cells	319.40	5	63.18	
Between Groups (RHip 180PT)				
Group	69.34	1	69.34	.823
Within cells	7598.60	6	1266.43	
Within Groups (RHip 180PT)				
RHip (time)	10.84	1	10.84	.744
Group x RHip	19.84	1	19.84	.660
Within cells	556.60	6	92.77	
Between Groups (RHip 180AT)				
Group	51.34	1	51.34	.855
Within cells	8459.60	6	1409.93	
Within Groups (RHip 180AT)				
RHip (time)	.04	1	.04	.982
Group x RHip	.04	1	.04	.982
Within cells	410.40	6	68.40	

TABLE VIII (continued)

Source	SS	df	MS	F
Between Groups (RHip 300PT)				
Group	.20	1	.20	.988
Within cells	5411.73	6	901.96	
Within Groups (RHip 300PT)				
RHip (time)	85.20	1	85.20	.558
Group x RHip	1.20	1	1.20	.944
Within cells	1331.73	6	221.96	
Between Groups (RHip 300AT)				
Group	3.27	1	3.27	.947
Within cells	4140.73	6	690.12	
Within Groups (RHip 300AT)				
RHip (time)	43.35	1	43.35	.618
Group x RHip	1.35	1	1.35	.929
Within cells	941.40	6	156.90	
Between Groups (BFat)				
Group	83.78	1	83.78	.029**
Within cells	61.20	6	10.20	
Within Groups (BFat)				
BFat (time)	12.51	1	12.51	.006**
Group x BFat	1.38	1	1.38	.214
Within cells	4.30	6	.72	

RKnee - right knee RAnkle - right ankle RHip - right hip
PT - peak torque AT - average torque
BFat - body fat
30 - 30 degrees per second
180 - 180 degrees per second
300 - 300 degrees per second
** - significant at $p<.05$

Discussion of the Results

While significant differences were detected at the .05 level, post hoc testing revealed there were no significant changes from pretesting to posttesting (time) within either group (including the weight training group), nor were there any significant differences between groups in posttesting. There are several possible reasons for the absence of significant peak torque improvements in the 3 joint movements tested.

The Effects of Concurrent Aerobic and Anaerobic Training on strength

While it is normally expected for resistance training to elicit improvements in strength (33), numerous studies have demonstrated a compromise in strength gains in subjects involved in training programs simultaneously utilizing aerobic and anaerobic (resistance training) protocols. One such study of 10 weeks (18) demonstrated a significant compromise of strength improvement for a one repetition maximum squat (1RM) in a combination endurance/strength group when compared to the 1RM gains in a strength training only group. While both groups made significant gains in the squat 1RM over a 10 week period, the combination strength/ endurance group peaked on the 7th week (34% gain over pretest) and declined to 25% by the 10th week. The strength training only group improved 44% over pretest measures. The combination strength/endurance group performed both the strength program and the endurance program which consisted of 6 bouts per week alternating cycling and running. Cycling consisted of 6 sets of 5 minute work bouts at intensities close to VO2 Max, while the running program progressed up to 40 minutes of running by the completion of the study. It should be mentioned at this point that the loads in the present study were considerably less than the loads used in the Hickson study, which may possibly explain the absence of strength gains in the present study while significant gains were achieved in the Hickson study. This issue will be explored later in the discussion. It is evident, though, from the Hickson study that endurance training has a deleterious effect on strength improvements.

In a study by Dudley and Djamil (11), strength trained only and combination strength/endurance trained subjects were compared at 7 angular velocities (ranging from 0.00 rad/second to 5.03 rad/second) to determine the effects of aerobic training on strength. 22 previously untrained subjects participated in a 7 week study. While the strength training only group made significant improvements in angle-specific torque at angular velocities of 0.00 to 4.19 rad/second, the combination group improved only in torque at the lower angular velocities (0.00 to 1.68 rad/second). Data also shows that the improvements made by the combination group, even at the slower velocities, were less than the gains made by the strength training only group.

In a third study by Ono et al. (39), moderate distance running had a deleterious effect on male subjects' vertical jump, a high force production movement with a similar muscle fiber recruitment as that in resistance training. Subjects, ages ranging from 30 to 71 years, experienced a decrement in vertical jump ranging up to 18 percent. Subjects with the greatest improvements in VO2 max and running times to exhaustion had the greatest decreases in the vertical jump.

One possible explaination for this phenomenon is that long-term low-intensity exercise (characteristic to aerobic activity such as distance running) elicits a biochemical adaptation at the cellular level in skeletal muscle. These changes include an increase in myoglobin content, capillary density, and mitochondrial enzymes (15). These adaptations, especially those involving aerobic enzymes, have the total effect of converting fast twitch (type IIa,IIb) into slow twitch (type Ia) fibers (15,21). The net effect of these adaptations would enhance aerobic capacity in humans but hinder the ability to exert force as is required in activities requiring strength and power.

A second possible explaination for the decrement in strength in combination strength/endurance training is related to the subjects' trainability status. Male distance runners have been found to have lower testosterone concentrations than control subjects (50). Depressed elevations of total and free testosterone inhibit the anabolic activity required to enhance strength.

In light of the previously cited studies, several possible solutions can be suggested as to why no strength enhancement was observed in the present study in either the bench stepping or resistance training groups. First, the female subjects in the present study were involved in a combination strength/endurance program. In the absence of any distance running, it more likely the subjects involved in the present study would have experienced at least modest strength gains. Running volume (see Table V) was sufficient to dilute any anabolic training effect that may have been derived from either treatment group. Subjects were also trained female distance runners with a minimum of one year of competitive distance running experience. The trainability status (hormonal) also may have been a contributing factor in the failure of subjects to realize any improvement in peak torque. In summary, the effects of high volume distance running combined with a preexisting trainability status in the subjects, unconducive to the possible anabolic training effects of either or both treatments, may have diluted any potential augmentations in peak torque in this study.

Resistance Training Intensity (Percent of 1RM)

A second consideration in the failure of, in particular, the resistance training group to experience any strength gains is related to the training loads (%1RM). Although it is commonly suggested (16) that endurance runners not utilize heavier loads in training, no studies to date confirm this practice. Due to the subjects' lack of resistance training experience and the common assumption and practice of coaches and strength conditioning professionals to use loads of moderate intensities (12-15RM), the researcher in the present study elected not to require subjects to test fora 1 RM in any of the resistance exercises. Loads for the resistance training group were selected in accordance to the individual subject's ability to perform 15 repetitions comfortably while maintaining proper form and mechanics. As previously observed, no research has been conducted specifically with distance runners as to what are considered appropriate (but not excessive) loads. The effects of distance running may require heavier load requirements than have been traditionally suggested.

The Low-Intensity Nature of Bench Stepping

One of the purposes of this study was to determine if any strength gains may be observed in a low-intensity, long-duration activity such as bench stepping. Distance running (a low-intensity, repetitive activity which involves a muscle fiber recruitment pattern utilizing almost exclusively fiber type I) has been shown to hinder explosive muscular contractions and convert, biochemically, fiber types IIa and IIb into fiber type I (21). While bench stepping may also be categorized in the same general class of exercise as long distance running, the researcher has observed anecdotal evidence of modest strength improvements in athletes engaged in a bench stepping program. One possible explanation of this observation is that the bench stepping program observed was done to the exclusion of all other activities, including running. As previously mentioned, the training effects of distance running in the present study may have diluted any anabolic effects elicited by bench stepping. Secondly, while no significant changes in peak torque was observed in any joint movement, closer examination of the pretest and posttest data (see Tables VI and VII) suggests that bench stepping was at least as equally effective in maintaining strength in the three joint movements as was the resistance treatment group.

Gender and Age of Subjects

It is well established from literature that females have disporportionate levels of free testosterone in comparison to males (23,29). Adolescent females have approximately 25% of the free testosterone levels as that of their male counterparts. Subsequently, female adolescent athletes will possess a diminished proclivity toward protein synthesis in exercised muscles involved in resistance training. While this may be a partial explanation for the failure of the female subjects in the present study to improve peak torque, a majority of strength augmentation can be attributed in studies of 6 weeks or less to primarily neural factors (34). It is therefore unclear as to whether the gender of the subjects contributed to the results of this study.

Training Velocity Specificity

Studies involving isokinetic strength testing have revealed a specific training adaptation to a particular training velocity. In a 1981 study by Coyle (10), 3 groups trained at differing angular velocities. Group A trained at exclusively slow speeds (60 degrees per second, 5x6 at maximal effort), group B executed 5 sets of 12 maximal contractions at 300 degrees per second, while group C trained at both slow (2-3x6 at 60 degrees per second) and fast (2-3x12 at 300 degrees per second) speeds. The results clearly exhibited a training velocity specific adaptation in all groups. Again, while no statistically significant improvements were observed in the present investigation, closer examination of the raw data may express validity to the suggestion that training speed specificity could have influenced the results in the resistance training group. Although no angular velocities were measured during the training sessions, it is estimated that the loads in the resistance group were never sufficient to approximate angular velocities as low as 30 degrees per second. This fact may partially explain why the weight training group, while making non-significant gains in knee and ankle extension at angular velocities of 180 and 300 degrees per second, actually experienced a decrement in strength in those same joint movements at the slower angular velocity of 30 degrees per second.

Motivation

A common complaint among subjects during pretesting and posttesting was the duration of time involved with the collection of data. Excluding the measurement of the subject's weight and bodyfat, 18 sets requiring maximal effort were performed over a time period of approximately 2 to 3 hours. This was due to the need for each subject to fully recuperate from the previous set before beginning the next set. In addition, the LIDO Isokinetic System requires approximately 5 to 7 minutes to set-up for each joint movement tested. Observations by the researcher led to the anecdotal conclusion that fatigue and boredom may have played some role in the motivation of the subjects. While this superficially may appear to effect the results of the findings in this study, both resistance training and bench stepping groups pretested and posttested under the same conditions. Therefore the effects of the lack of motivation in the subjects would be nullified.

Number of Subjects

One apparent shortcoming in the study was the small number of subjects. With larger samples, there is a much higher probability of a normal distribution of subjects' scores. As in the case of the present study, the small number of subjects increases the likelihood of an erratic and ill-defined distribution. It is possible that the subjects' scores on pretest and posttest did not reflect a normal population and therefore skewed the results.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter includes a brief summary of the research, a list of the findings, a list of the conclusions, and a list of recommendations for further research.

Summary

In recent years, bench stepping has emerged as a popular mode of aerobic exercise. While bench stepping has been demonstrated to elicit an aerobic training effect similar to other modes of endurance training, no study has researched the possible strength improvements that may occur in addition to the cardiovascular benefits. The purpose of this study was twofold; (1) to determine if strength gains occur in an 8 week progressive bench stepping program and (2) to compare any potential strength gains from bench stepping to the strength gains derived from a traditional progressive resistance program for distance runners.

Eight trained teenage female distance runners from a high school cross country team volunteered for the study. Subjects were pretested and posttested on a LIDO Isokinetic System at angular velocities of 30, 180, and 300 degrees per second in hip extension, knee extension, and ankle plantar flexion during the summer of 1992. After pretesting, five subjects underwent an 8 week bench stepping and distance running program while the other treatment group (n=5) participated in an 8 week program of moderate intensity resistance training and distance running. Subsequent to the two treatments, both groups posttested on the LIDO Isokinetic System at the same angular velocities for the same 3 joint movements. Two subjects, both in the weight training group, failed to complete the study due to factors unrelated to the study.

Results of the two-way MANOVA indicated no significant differences in mean peak torque within groups from pretest to posttest or between groups in the posttest when mean scores were analyzed using the Newman-Keuls Multiple Range Test for post hoc examination. The findings suggest that bench stepping does not significantly enhance peak torque in trained teenage female distance runners while simultaneously participating in a running program of 18 to 25 miles per week. Secondly, bench stepping provided for the maintainence of strength in trained female distance runners at levels that are comparable to those elicited by a traditional resistance training program of moderate intensity (10-15 repetitions).

Summary of the Findings

Hypothesis #1. There will be no significant difference in mean pretest and posttest isokinetic strength scores in the resistance training group. (accepted)

Hypothesis #2. There will be no significant difference in mean pretest and posttest isokinetic strength scores in the bench stepping group. (accepted)

Hypothesis #3. There will be no significant difference between the two research groups in posttesting isokinetic strength scores. (accepted)

Conclusions

Based upon the findings of this study, the following conclusions are submitted:

1. A program of bench stepping maintains, but fails to augment, strength of the lower extremity in trained teenage female distance runners while simultaneously engaged in a distance running program of moderate volume.

2. The efficacy of bench stepping to maintain lower extremity strength in trained teenage female distance runners is comparable to the training adaptations derived from a traditional resistance training program when athletes are engaged concurrently in distance running of moderate volumes (18-25 miles per week).

Recommendations for future research

Based upon the findings of the present study, the following recommendations are suggested for future research:

1. Conduct a study investigating the strength gains

of an 8-12 week bench stepping program with subjects not involved in a concurrent distance running program.

2. Conduct a study comparing the effects of varying heights of benches on strength improvements.

3. Research the possible strength improvements of bench stepping with and without hand weights in subjects participating and not participating in concurrent distance running.

4. Utilize both male and female subjects in the previously recommended studies.

5. Investigate the efficacy of a periodized mesocycle-length resistance program (4 weeks of 5x10-RM at 75-80% of 1RM, 4 weeks of 6x8-RM at 85% of 1RM, 4 weeks of 3x6-RM at 90% of 1RM, and 4 weeks of 3x3-RM at 95% of 1RM) on strength improvement in athletes engaged in a concurrent distance running program.

6. It is strongly recommended by the researcher that future studies utilizing multi-joint resistance movements as a treatment incorporate an orientation period of two or more weeks if untrained subjects are used. Based upon anecdotal observations by the researcher in the present study, this time period is necessary to adequately educate untrained subjects as to the correct mechanics of the movements involved as well as allowing a proper time frame for the subjects' motor coordination to adapt to the novel movements. This orientation period will allow the subjects to perform a 1RM in all resistance movements to be included

in the treatment, thus the relative intensities of the loads used during the study may be more accurately estimated.

7. Utilize a larger sample size than used in the present study.

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APPENDIX A

OKLAHOMA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD PERMISSION

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
FOR HUMAN SUBJECTS RESEARCH

Date:
0-12-92 **IRB#:** Ed-92-068

Proposal Title: BENCH STEPPING AND RESISTANCE TRAINING: A COMPARISON OF STRENGTHS GAINED IN TRAINED HIGH SCHOOL FEMALE DISTANCE RUNNERS

Principal Investigator(s): Bert Jacobson/Michael Reed

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR 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 Reasons for Deferral or Disapproval are as follows:
COMMENTS:

It appears those conducting this research are males. Since the subjects are High School females and given the fact that body measurements are to be taken, would it be advisable for precautions to be taken in this regard? Should the measurements be taken by a female or should there be a female present?

In order to participate in distance running, will the subjects have received medical clearance prior to the research? If not, would it be advisable for this to be required?

The Informed Consent Form needs to specify who will have access to the data that is to be done with it at the conclusion of the study.

Signature: John H. Wyckoff Date: July 7, 1993
Chair of Institutional Review Board

APPENDIX B

INFORMED CONSENT FOR ISOKINETIC STRENGTH

TEST AND EXERCISE TREATMENTS

INFORMED CONSENT FOR ISOKINETIC STRENGTH TEST AND EXERCISE TREATMENTS

The exercise test you are about to undergo is to determine the strength of your hip extensors, knee extensors, and ankle plantar flexors. The test will be before and after the 8 week exercise program you will participate in to determine the strength gains, if any, at the three previously mentioned joints.

Explanation of the Exercise Test

You will be tested on the LIDO Isokinetic System to determine the strength of your hip extensors, knee extensors, and ankle plantar flexors. You will be tested at the three following velocities of muscle contraction: (a) 30 degrees per second x 3 repetitions, (b) 180 degrees per second x 15 repetitions, and (c) 300 degrees per second x 15 repetitions. You will be asked to exert maximal effort for the required number of repetitions on both your left and right legs. You will be given sufficient rest between each joint segment test. While this isokinetic strength test is used extensively with healthy and diseased/injured individuals, the slight possibility of musculoskeletal injury (pulled or strained muscles, ligament sprain, etc.) exists even in healthy individuals. You also may experience some muscle soreness in the days following the test. You should not participate in this study or this test if you suffer from any of the following conditions: acute or sub-acute strain and/or ligament strain, history of degenerative or rheumatoid arthritis affecting the tested joints, history of surgery on the hip, knee, or ankles, patellar tendonitis, or knee bursitis. The test will be supervised by a Licenced Physical Therapist and a Certified Strength and Conditioning Specialist.

Explanation of the Exercise Program

You will participate in one of the following exercise programs for eight consecutive weeks: either a distance running program supplemented with resistance training, or a distance running program supplemented with bench stepping. The long distance running program will progress from a total of 18 miles the first week to 25 miles the eighth week. The bench stepping program will progress from 15 minutes duration at 24 steps/minute to 40 minutes at 30 steps/ minute. Bench stepping will be conducted 4 times per week. The resistance training program will be performed mainly on free weights and supplemented with some machines. You will be instructed on the proper lifting technique on each lift as well as all of the safety precautions involved with strength training. Both the running/lifting and stepping/ running groups will exercise 4 times/week for about 2 hours a day. These 2 hours will include both a warm-up and a cool down as well as the workout. Neither workout program is considered an uncommon workout protocol for competitive teenage female distance runners.

With the paticipation in resistance training, there exists a very slight risk of injury to muscles, tendons, and ligaments such as strains, tears, and dislocations. The risk is greatly increased if correct form in each lift and observance of safety precautions are not adhered to by the participants. Likewise, aerobic exercise (running and bench stepping) can elicit adverse effects such as the following: (a) structural injuries such as knee injuries, shin splints, ankle sprains, foot injuries, and other over-use injuries, (b) cardiovascular events including heart attack, stroke, heat stroke, and heat exhaustion, and (c) metabolic problems as a result of carbohydrate depletion. While adverse structural and metabolic effects are a mild risk for healthy populations, adverse cardiovascular events are extremely rare in healthy individuals. While the intensities of the exercise programs are moderate, you may experience some discomforts such as elevated heart rate, rapid breathing, muscle soreness, and muscular stiffness. These discomforts should be minimal and lessen as you progress into the exercise program. You should not participate in this study if you have or develope during the study any of the following conditions: (a) a pre-existing cardiovascular disease, (b) back problems, (c) chest pain, (d) severe dizziness, or (e) pain in the joints or muscles that worsens over time.

All workouts will be supervised a Certified Strength and Conditioning Specialist with CPR certification. In the case of injury, normal school policy protocol will be followed in the acute treatment of the injury and/or the referral of the subject/student contingent upon the severity of the injury.

The information which is obtained from this study will be treated as priviledged and confidential. Your names will not be revealed or released in any way without your permission. The information derived from this study will, however, be treated in an aggregate manner to provide group information.

Consent by Subject and Parental Consent

I understand that participation in this study is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this study at any time without penalty after notifying the research study director. I have read the foregoing and I understand it and all that is involved. Any questions that I have had have been answered to my satisfaction. I sign this form freely and voluntarily. A copy has been given to me.

You may contact Dr, Bert Jacobson at telephone number (405) 744-5504 should you wish further information about the research. You may also contact Beth McTernan, University Research Services, 001 Life Sciences East, Oklahoma State University, Stillwater, OK, 74078; telephone: (405) 744-5700.

Date______________________________

Signed____
(signature of subject)

Signed____
(parental consent)

Signed____
(physical therapist)

I certify that I have personally explained all elements of this form to the subject and his/her parent/guardian before requesting them to sign it.

Signed____
(study director)

APPENDIX C

DESCRIPTION OF RESISTANCE EXERCISES

Description of the Squat (7)

1. The bar is evenly loaded with collars.
2. The height of the bar on the rack is approximately mid-chest high.
3. Hands are placed evenly on the bar (pronated) using a slightly wider than shoulder-width grip.
4. Step under the bar with both feet.
5. Place the upper back in the center of the bar, bar rests across posterior deltoids and the middle of the trapezius.
6. Chest is held up and out while shoulder blades are pulled together.
7. Straighten both legs to lift the bar off the rack and take one step back.
8. Position the feet approximately shoulder width or wider apart with toes pointed slightly out.
9. Feet remain flat on the floor throughout the movement.
10. Head faces straight forward throughout the movement.
11. Torso is held straight and rigid throughout the exercise.
12. Start descent by slightly bending forward at the hips first, then bending the knees.
13. Weight is over the middle of the foot or heels, not the toes.
14. As the knees bend, they should stay over the ankles.
15. Descend slowly (45 degrees per second) until tops of thighs are parallel to the floor.
16. In the ascent, push the bar with the legs to the starting position.
17. The ascent should be done rapidly but under control.
18. Keep the hips under the bar as much as possible.
19. Do not shift the knees (squeeze) toward one another.

20. Use a smooth motion; do not "jam" or accelerate the bar at the top of the movement.

21. To rack the bar, step back to the rack taking small steps with both feet after a set is completed.

22. "Sit back" in the down phase (do not shift forward).

23. Do not bounce at the bottom.

24. Inhale at the top before lowering the bar, hold breath during the descent, and slowly exhale during the ascent.

25. If the hips are too forward, the torso will be too upright.

26. Avoid rounding the back.

27. Don't squeeze knees together.

28. Always use a lifting belt.

Description of the Dead Lift (13)

1. Place the bar on the floor in front of shins
2. Keep feet approximately shoulder width
3. Grap the bar approximately shoulder width using a switch grip (one hand supinated, one hand pronated).
4. Squat down keeping head up back straight or slightly arched.
5. Pull the weight past knees until body is fully erect.
6. Under control return the bar to the floor.

Description of the Glute-Ham Raise (31)

1. Athlete will be facing down on a glute-ham raise bench.
2. Position legs so that knees are slightly below the thighs support pad and so that the pad is actually hitting thighs.
3. Athlete's body will form a right angle in the starting position with hips over the thigh pad.
4. Begin by raising trunk until whole body forms a straight line parallel to the floor.
5. Head is facing forward or slightly up (extended).
6. Hands can be placed on each side of head or across the chest.
7. Once the body is parallel to the floor, pull with the hamstrings (knee flexion) until the top position is reached (45-90 degrees to the floor).
8. Descend slowly to the starting position and repeat.
9. Make sure the body is in a parallel position to the floor before initiating knee flexion.
10. Avoid hyperextending the lower back.
11. Make certain all apparatus adjustments are locked and tightened.
12. Make certain feet and heels are secure and unable to slip.

Description of Back Raise (13)

1. Lie down on glut-ham bench with upper body hanging off the pad (pad should be positioned to where the iliac crest of the pelvis is resting on the pad).

2. Lift the torso up (trunk extension) until aligned with the legs (parallel to the floor).

3. Slowly return to the starting position and repeat.

Description of knee raise (hip flexor)

1. Start by standing on step-up bench, one foot close to the edge, the exercised leg over the side of the bench.

2. Hook a looped rope with a weight attached over the foot of the exercised leg, the rope being held on by dorsiflexing the ankle.

3. Body stability and balance is maintained by the opposite arm (of the exercised leg) holding on to a stationary object such as a power rack.

4. Commence hip flexion of the exercised leg until knee is in front of the chest.

5. Slowly return leg to the starting position (leg will be perpendicular to the floor.

Description of the Abdominal Crunch (13)

1. Lie on your back on the floor, placing your feet on a bench (creating right angles at the hips and knees).

2. With arms folded across the the chest, flex your trunk (not the hips) by raising the shoulder blades off of the floor (approximately 30 degrees flexion).

3. Head, neck, and upper back should remain in an isometric contraction.

4. Only the rectus abdominus should contract.

Description of the Bench Press (13)

1. Lie supine on the bench with feet firmly planted on the floor.
2. Grasp the bar approximately shoulder width a pronated (palms forward) grip.
3. Remove the bar from the rack and hold bar fully extended.
4. Slowly lower bar to the chest and return to a fully extended position.
5. The bar should follow an elliptical path, during which the weight moves from a low point on the chest to a high point over the eyes.
6. Avoid arching the neck or the lower back.
7. Never bounce the weight off of the chest.

Description of the Push Press (42)

1. Take bar from supports to a position on the anterior deltoids above the clavicles.
2. Use an even pronated grip slightly wider than shoulder width, thumbs around the bar.
3. Elbows are below and in front of the bar.
4. Stance is approximately shoulder width.
5. Torso is straight, rigid, and upright throughout movement.
6. Head is tilted backward slightly.
7. A slight dip is initiated by bending the knees and hips while the torso remains upright.
8. Keep bodyweight on the balls and heels of the feet.
9. With no pause at the bottom of the dip, the legs are forcefully extended, going straight up on the toes (plantar flexion).
10. With the aid of the leg drive, the bar is pressed overhead until arms are fully extended.

11. The bar should finish directly over the head of the athlete.

12. Return bar to starting position under control.

13. Inhale before dip is initiated, hold breath during the dip and leg drive, and exhale as the bar is locked out overhead.

Description of the Lat Pulldown (13)

1. From a seated position, grasp the bar of the lat machine with a supinated grip, at shoulder width.

2. Pull the bar down slowly to the upper chest approximately just below the clavicle.

3. Flexion occurs in the elbows but is due primarily to shoulder joint extension.

4. Inhale and hold your breath as you pull down the weight and exhale as you slowly return the weight the starting position.

5. Athlete may lean back slightly.

6. At the bottom of the movement, pull shoulders back; causing the chest to stick-out more.

Description of the Dumbell Pullover (13)

1. Athlete should lie perpendicularly on the bench, with head hanging off of the bench.

2. The single dumbell should be held by both hands. Do not grasp the handle but instead place both hands flat against the inside of the weights, palms facing away from the face.

3. With elbows slightly flexed, slowly lower the bar back to a position where the arms are parallel to the floor.

4. Slowly return the weight to the starting position.

5. Inhale while lowering the weight, exhale while performing the concentric portion of the movement.

Description of the Dumbell Front Raise (13)

1. From a standing position (shoulder width), dumbells in both hands with weights placed in front of the thighs, raise the dumbell (alternating one arm at a time) to approximately eye level.

2. Slowly lower dumbell back to starting position.

3. Avoid arching back. Keep body stabile and solid in an isometric contraction.

4. A slight bend in the elbow is suggested.

5. Avoid using excessive weight.

Description of the Hammer Curl

1. Start with feet shoulder width, arms extended down to the side while holding the dumbells in a neutral position (neither pronated or supinated, but palms facing the body).

2. Alternating one arm at a time and keeping the upper arm stationary, curl (elbow flexion) the dumbell completely while keeping hand in the neutral position.

3. Avoid using excessive weight and arching the lower back.

APPENDIX D

DESCRIPTION OF BENCH STEPPING

Description of Bench Stepping

1. Position at the start should be approximately 12 inches behind the bench (subject should face bench).

2. Subjects will step up and down on the bench to the beat of the music (either 24 or 30 repetitions per minute).

3. One complete repetition is as follows: left leg steps onto the bench, right leg pushes off the ground and steps onto the bench, left leg steps back down to the ground while right leg remains on the bench, right leg returns to the ground. This will return the subject to the starting position ready to perform the next repetition.

4. Every minute,at a verbal command to switch, subjects will lead with the alternate leg.

5. Every odd numbered minute (1,3,5, etc...), subjects will lead with the left leg, every even numbered minute (2,4,6,etc....) subjects will lead with the right leg.

6. Subjects will make every effort to step exactly with the cadence of the music.

7. Arms are kept flexed at a 90 degree angle similar to that of running during bench stepping extending and flexing slightly at the shoulder.

8. Arm cadence is the same as that of the legs.

9. The opposite arm is extended simultaneously with the lead leg (left leg lead requires right arm extending first to offset any lateral rotation, keeping all movement in the sagittal plane).

APPENDIX E

WEIGHT ROOM SAFETY INSTRUCTION

Weight Room Safety Instruction

1. All subjects must wear lifting belts on lifts placing stress in the vertebral column (squats, push press, curls dead lifts, etc...).

2. Always use spotters on squats and bench presses.

3. Use collars on all lifts.

4. Never drop the weights.

5. If spotters are forced to assist a lifter on an unsuccessful attempt, the lifter should stay with the bar until the bar is racked by the spotters. Do not bail out.

6. Always warm-up for each new exercise.

7. Stay with the prescribed exercise program. Don't try a lift that you have not been taught.

8. Think form and technique first. If you cannot perform the prescribed loads or repetitions with proper form, don't continue.

VITA

Michael E. Reed

Candidate for the Degree of

Master of Science

Thesis: BENCH STEPPING AND RESISTANCE TRAINING: A COMPARISON OF STRENGTH GAINS IN TRAINED HIGH SCHOOL FEMALE DISTANCE RUNNERS

Major Field: Health, Physical Education, and Leisure

Biographical:

Personal Data: Born in Seminole, Oklahoma, August 30, 1956, the son of Joe and Margaret Reed.

Education: Graduated from Shawnee High School, Shawnee, Oklahoma, in May 1974; received Bachelor of Arts in Physical Education from Oklahoma Baptist University at Shawnee in May, 1981; completed requirements for the Master of Science degree at Oklahoma State University in July, 1993.

Professional Experience: Physical education teacher, Grove Elementary School, Shawnee, Oklahoma, 1981, to 1984; Teaching Assistant, Department of Kinesiological Studies, University of North Texas, 1985 and 1987; Physical education teacher, Will Rogers Elementary School, Shawnee, Oklahoma, 1989, to 1992; Head Boys and Girls Cross Country and Track coach, Shawnee, Oklahoma, 1990, to present.

Professional Organizations: National Strength and Conditioning Association, Oklahoma Track Coaches Association, Oklahoma Girls Track Coaches Association.

Professional Certifications: Certified Strength and Conditioning Specialist, Certified Level I Track and Field Coach.