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The effects of a 12 week aerobic bench stepping conditioning program on cardiorespiratory fitness and muscular leg strength in college women

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University of Nevada, Las Vegas, 1991

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The Effects of a 12 Week Aerobic Bench Stepping Conditioning Program on Cardiorespiratory Fitness and Muscular Leg Strength in College Women.

By
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A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of
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ABSTRACT

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The Effects of a 12 Week Aerobic Bench Stepping Conditioning Program on Cardiorespiratory Fitness and Muscular Leg Strength of College Women.

Director of Thesis: Lawrence A. Goiding, Ph.D.

The purpose of this invesitgation was to examine the effects of a 12 week aerobic bench stepping conditioning program on maximum oxygen uptake, time on treadmill and muscular leg strength, measured by knee flexion and extension strength, on college women ranging in age from 18 to 25 years. Prior to a twelve week conditioning period subjects were assessed for maximum oxygen uptake (VO_2 max) and time on treadmill (TOT) using a graded treadmill test. Musular leg strength was measured using Bally's Life Fitness Machines, averaging three maximum knee flexion lifts and extension lifts. These same measurements were repeated following the 12 week aerobic bench stepping conditioning program. Results of the analyses indicated that the aerobic bench stepping period was of sufficient intensity, frequency and duration to elicit favorable

responses in VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$) ($P<.05$), VO_2 max ($L \cdot min^{-1}$) ($P<.05$), and Knee Extension Strength ($P<.01$). However, this training regimen did not favorably alter Time on Treadmill or Knee Flexion Strength.

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Chapter 1

Introduction

The increase in health, wellness and exercise awareness for the past 20 years has motivated individuals to engage in a variety of new physical activities. Aerobic dance is one such physical activity that claims to be beneficial for cardiorespiratory fitness, muscular strength and muscular endurance. The increase in popularity in aerobic dance can be seen by the greater selection of classes offered and the number of participants in the classes, both in fitness centers and in health clubs. Class size and number of participants have continued to increase as considerable research has been done on the physiological effects of aerobic dance (Cearly, Moffatt, & Knutzen, 1984; McCord, Nichols, & Patterson, 1989; Hopkins, Murrah, Hoeger, & Rhodes,1990). The research supports the positive changes that occur as a result of aerobic dance training.

Original aerobic dance programs consisted of choreographed combinations of various dance forms including dance, modern jazz and callesthenic-type exercises. A recent innovation of aerobic dance is "Bench Stepping" or "Step Aerobics". Step aerobics is a modified low impact exercise program that utilizes an individualized platform with heights ranging from 4 to 12 inches. As an aerobic bench routine is performed, a participant steps up and down between their platform and the floor to suitable music. This exercise utilizes the cardiovascular system as well as muscles in the upper and lower extremities.

Although aerobic bench stepping is new, bench stepping has actually been in the research literature for the last fifty years (Golding, 1989). The 3 minute step test is a traditional cardiorespiratory fitness assessment tool (Golding, 1989) and is currently utilized in the YMCA fitness test battery. Stepping up and down on a bench is also currently used in rehabilitation programs to strengthen and rehabilitate post operative and injured knees. Stair climbing machines, such as the "Stair Master 4000" are increasing in popularity in university weight rooms, physical therapy clinics, hospitals, health clubs and YMCA's located around the country. In addition, bench aerobics appeals to a wide range of participants, both men and women, for several reasons: once the basic routines are learned, they are easy to follow; routines are basic and not as dancy as normal aerobic dance routines and even the most uncoordinated person finds aerobic bench attemptable; it allows participants to work at a high intensity level with low-impact force to the joints; and applies seemingly minimal stress to the musculoskeletal system.

Need For The Study

Several researchers have examined the energy cost of aerobic dance routines and have concluded that aerobic dancing can be useful in changing physical fitness (Foster, 1975; Weber, 1974). Studies have also investigated the training effects of aerobic dancing and have found that aerobic dance is similar to other aerobic activities such as running and swimming and when done at sufficient intensity, frequency and duration have produced cardiorespiratory adaptations

(Rockefeller and Burke,1979; Hooper and Noland,1984; Clearly, 1984; Watterson, 1984). However, no experimental training studies have looked specifically at the training effects of aerobic bench stepping.

It is well established that aerobic activities produce cardiorespiratory adaptions, so any activity that stresses the cardiovascular system should increase physical fitness. In new activities, such as aerobic bench stepping, claims are based on this deduction. Both the amount of cardiovascular conditioning and the changes in leg strength that may result from this activity need to be measured in order to confirm or contradict claims that support the benefits of aerobic bench stepping.

Statement of the Problem

The purpose of this study was to quantify the cardiorespiratory and leg strength changes that result from a 12 week aerobic bench stepping program.

Assumptions & Limitations

In every study certain unavoidable assumptions and limitations are present. The major assumptions and limitations are listed below.

1. Maintaining desired intensity throughout the stepping sessions was assumed to be controlled by the subjects. Subjects were taught how to monitor their pulse at either the radial or carotid artery sites during stepping sessions, to maintain the desired intensity.

2. It was assumed that an eight inch bench height was appropriate for all subjects, considering the following factors: leg strength, initial fitness level and whether or not subjects had a predisposition to orthopedic problems (ie. knee soreness or previous knee surgery)

3. The experimental period was twelve weeks in duration for a total of twenty-nine, 45 minute sessions. Three sessions were missed due to state or national holidays.

4. For the duration of the study, subjects were asked not to alter their eating or exercise habits. It was assumed by the experimenter that these habits were maintained through out the study. Subjects filled out daily activity summary sheets to monitor activity throughout the semester.

5. The number of subjects was minimal to allow inferences to be made about the general population. Fourteen subjects participated in the study; all were college age females between 18 and 25 years of age.

6. Maximal oxygen uptake (VO_2 max) was assumed to be reached when the oxygen uptake did not increase with an increase in workload, or if there was a drop in VO_2 max. If these criteria were not met then maximal oxygen uptake was assumed to be attained when subjects reached voluntary exhaustion.

Chapter 2

Literature Review

Introduction

Dr. Kenneth Cooper popularized the word "Aerobics" to represent a cardiorespiratory exercise program, one that included activities such as swimming, running and bicycling (Cooper, 1968). Five years later, Jacki Sorenson pioneered a choreographed exercise program which became known as "Aerobic Dance" (Sorenson, 1973). Aerobic Dance was a combination of dance movements that involved rhythmic hopping, jumping, skipping, sliding, and stretching, all designed to be aerobic in nature and improve cardiorespiratory endurance.

Several studies have been conducted to show that aerobic dance exercise improved cardiorespiratory efficiency (Cearly, 1984; Dowdy, Cureton, DuVal, & Outzs, 1985; Watterson, 1984; and Hooper, 1984). Studies have also shown that exercise quantification (intensity, duration, and frequency) was a critical factor in order for cardiorespiratory changes to take place (Eickhoff, Thorland, & Ansorge, 1983). By applying the appropriate intensity, frequency and duration, aerobic dance may be choreographed in such a way that a routine could be instructed at three different intensities: low, medium, and high. Low intensity aerobic dance was designed to be equivalent to walking, medium intensity to jogging, and high intensity to running (Igbanugo and Gutin, 1978).

Typically, the cardiorespiratory changes that have been found to occur from aerobic activities such as running, swimming and bicycling include decreased resting heart rates (Wilmore, 1969; McArdle, Katch, & Katch, 1986) and decreased submaximal exercise heart rates (Ekblom, Astrand, Saltin, Stenberg, & Wallstrom, 1968; Fox, Kirby, & Fox, 1987; McArdle, 1986). Studies have shown that aerobic dance can produce similar cardiorespiratory results as measured in other modalities (Rockefeller and Burke, 1979; Vaccaro and Clinton, 1981; and McCord, 1989). These studies have shown that body composition, VO_2 max, resting heart rate and subjects' time on treadmill have changed significantly as a result of an aerobic dance training program. Other aerobic dance studies (Weber, 1974; Foster, 1975; and Igbanugo and Gutin, 1978) have shown that the amount of energy expended, while potentially adequate to produce a training effect, depends significantly upon the intensity of the dance.

Early Studies on the Physiological Requirements of Aerobic Dance

Weber (1974) found that the mean oxygen uptake values for ten aerobic dance instructors who performed low, medium and high intensity routines were 13.8, 21.1 and 28.32 $ml \cdot kg^{-1} \cdot min^{-1}$ respectively. The energy costs of the three intensities were as follows:

1. The low intensity elicited 3.8 $kcal \cdot min^{-1}$ which was comparable to activities such as golf, walking at 5.6 km/hr and pitching horse shoes, (Schuberg, 1984)

2. The medium intensity elicited 6.2 $kcal \cdot min^{-1}$ which was comparable to brisk walking or ice skating, (Schuberg, 1984)

3. The high intensity elicited 8.8 $kcal \cdot min^{-1}$ which was comparable to jogging at 5.5 mph or swimming the crawl stroke at 55 yards per minute (Schuberg, 1984).

Heart rates measured immediately following aerobic routines ranged from 160 to 220 beats per minute. Mean heart rate was not available. Weber (1974) concluded that aerobic dance, at a high intensity for a long enough duration, could provide adequate physiological stimulus to elicit a training effect.

In a similar study, Foster (1975) examined oxygen uptake values of four female subjects while they performed a specific aerobic dance routine. The group mean oxygen uptake value of 33.6 $ml \cdot kg^{-1} \cdot min^{-1}$ was in general agreement with Weber's data (Foster, 1975), and was found to be comparable to running at a 12 minute/mile pace. The greatest rate of oxygen consumption found during any full minute was 39.2 $ml \cdot kg^{-1} \cdot min^{-1}$ and was found to be comparable to running at a 9.5 minute/mile pace. The mean and peak oxygen consumption represented 77% and 90%, respectively, of the subject's VO_2 max.

Laboratory data available in Weber's study (1974) reflected similar trends as the data found by Foster. After assessing the two

data sets, Foster concluded that aerobic dance could elicit an oxygen consumption of approximately 30 $ml \cdot kg^{-1} \cdot min^{-1}$ for periods of time ranging from 5 minutes to 30 minutes and could elicit a cardiorespiratory training effect (Foster, 1975).

Rockefeller and Burke (1979) and Igbanugo and Gutin (1978) also concluded that aerobic dance, if performed at a moderate or vigorous intensity, could produce enough cardiorespiratory stress to increase aerobic capacity and improve cardiorespiratory fitness.

Igbanugo and Gutin (1978) investigated both male and female subjects while performing an aerobic dance routine. Low, moderate and high intensity dances, instructed by an experienced aerobic dance instructor, were video taped to control instruction consistency between subjects. Each dance intensity was measured by open circuit spirometry and heart rate. Expired gas was collected and analyzed so that VO_2 could be determined.

Low intensity dancing illicited mean steady state heart rates of 120 bpm in the women and 107 bpm in the men. At the medium intensity, the women averaged 152 bpm while the men averaged 135 bpm. At the high intensity, mean heart rates were 165 and 148, approximately 84% and 79% of age predicted maximum heart rate, for the women and men respectively. Igbanugo and Gutin concluded that the medium and high intensity aerobic dance routines that stressed the subjects at approximately 80% of max heart rate could provide adequate cardiovascular stress to influence the cardiorespiratory system.

Longitudinal Training Studies: A Review

Milburn and Butts (1983) compared aerobic dance to jogging in untrained female college students. During a seven week training study that met four days/week, for 30 minutes/day, subjects worked at an average intensity of 83-84% of maximal heart rate. Results demonstrated that both the aerobic dancers and joggers significantly improved their mean VO_2 max. VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$) increased 10% in both groups. The joggers improved from 36.4 $\pm$ 2.1 $ml \cdot kg^{-1} \cdot min^{-1}$ to 39.4 $\pm$ 2.6 $ml \cdot kg^{-1} \cdot min^{-1}$, while the aerobic dancers increased their mean VO_2 max from 35.4 $\pm$ 2.8 $ml \cdot kg^{-1} \cdot min^{-1}$ to 39.0 $\pm$ 2.0 $ml \cdot kg^{-1} \cdot min^{-1}$. Run time on a graded exercise test increased 21% and 14% for the dancers and joggers respectively. No significant differences were found between groups in training effects. Weight did not change significantly. The authors concluded that both jogging and continuous aerobic dance routines could produce similar improvements in cardiorespiratory fitness when performed at similar frequency, duration and intensity.

Rockefeller and Burke (1979) studied 21 college-aged women between the ages 19-24 years during a 10-week, three days per week, 40 minutes per day aerobic dance class. A control group was not used in the study. The class consisted of one five minute warm-up dance, seven aerobic dance routines for a 30 minute aerobic session and a five minute cool-down dance. Significant improvement in VO_2 max, submaximal heart rate and maximal perceived exertion were found. VO_2 max improved from 34.38 $\pm$ 1.57 $ml \cdot kg^{-1} \cdot min^{-1}$ to 38.79 $\pm$ 1.31 $ml \cdot kg^{-1} \cdot min^{-1}$ (12.8% increase). No significant change occured in body weight.

Watterson (1984) examined the effects of 60-minute aerobic dance sessions, three days per week for six weeks on cardiorespiratory fitness. Subjects were 16 women, new to aerobic dance. Significant improvement on the distance covered in Coopers 12-minute field performance test was found. The 12 minute test measured significant increases from 1.12 $\pm$ 0.12 miles to 1.28 $\pm$ 0.07 miles.

Cearly, et al, (1984) found significant improvements in VO_2 max in a 10-week, three days per week aerobic dance training program in 14 college females. The training session consisted of 10 -15 minutes warm-up, followed by 15 - 45 minutes of continuous aerobic dance routines. The early aerobic portions consisted of 15 minutes at 75% of maximum heart rate and progressed to 45 minutes by the sixth week. Training sessions concluded with 10-15 minutes cool-down. Results revealed a 10.7 % improvement in maximum oxygen uptake with the initial pretest mean VO_2 max at 40.1 $\pm$ 4.78 $ml \cdot kg^{-1} \cdot min^{-1}$ increasing to 44.5 $\pm$ 6.03 $ml \cdot kg^{-1} \cdot min^{-1}$. Body weight remained essentially unchanged (59.3 to 60.0 kg) through-out the study.

McCord, et al, (1989) examined VO_2 max, submaximal heart rate and body composition in a 12 week low impact aerobic dance conditioning program on 16 college age women, ages 17-29 years. Sessions consisted of a 5-10 minute warm-up, 30-35 minute low impact aerobic segment and a 5-10 minute cool-down. A small (8%) but significant mean increase in VO_2 max was found. Scores increased from 38.3 $ml \cdot kg^{-1} \cdot min^{-1}$ to 41.3 $ml \cdot kg^{-1} \cdot min^{-1}$. Submaximal heart rates at minutes 2-3, 3-4 and 4-5 of the graded exercise test

also decreased significantly. Percent body fat decreased significantly from 25 ± 6.8% to 21 ± 6.3% with no observed significant change in body weight.

Vaccaro and Clinton (1981) measured the effects of aerobic dance conditioning on the body composition and maximal oxygen uptake in ten college women. The women met three times a week in 45 minute sessions at unspecified intensity. No control group was used in the study. Both before and after the ten weeks of aerobic dance conditioning, the following parameters were measured: Height (cm), weight (kg), body composition, maximum heart rate (HR max), Ve max and VO_2 max. Body composition was measured by under water weighing and percent fat determined by the formula of Brozek, Grande, Anderson and Keys (Vaccaro and Clinton, 1981). Post test results revealed a significant increase in VO_2 max (23%). Pre-test mean scores were 31.11 ± 5.03 $ml \cdot kg^{-1} \cdot min^{-1}$ while post-test mean scores were 38.24 ± 7.32 $ml \cdot kg^{-1} \cdot min^{-1}$. The study revealed a slight increase in percent body fat from a pre-training value of 26.57 ± 4.92% to a post-training value of 27.2 ± 4.15%.

No underlying reason was found for the failure of aerobic dance to produce changes in percent body fat. Vaccaro and Clinton suggested that the small change may have been due to the short (10 week) training duration that did not allow training effects to become apparent. The authors concluded that in spite of the fact that other modes of training, such as swimming and running, have been shown to be superior to aerobic dance in improving VO_2 max, aerobic dance appears to provide sufficient cardiorespiratory stress to improve VO_2 max.

Leg Strength Training Studies

In one of the classic leg strength training studies, De Lorme (1945) reported on a rehabilitative exercise program used on 300 patients. Heavy resistance, low repetition exercises were designed mainly for the restoration of muscular strength in injured quadricep muscles of injured military service men. De Lorme recommended that patients exercise thirty minutes per day, five days a week. During one of these exercise sessions the patient was to exert one repetition maximum (1 RM), the most weight he could lift to complete one knee extension. This was recorded as the patient's maximum quadricep lift for that specific week. During the same testing session, the maximum weight that the patient lifted ten times (10 RM) was also determined and served as the basis of the patient's weekly exercise progression. The patient then went through his exercise program and during each workout session, lifted his 10 RM resistance load in sets of ten repetitions until 70 to 100 repetitions per session were completed.

Three years later, with the help of Watkins (1948), De Lorme revised the early study and found 70 to 100 repetitions per training session to be too high. In most cases, 20 to 30 repetitions resulted in similar changes. The authors then changed the original heavy resistance exercise term to progressive resistance exercise.

In a more recent study, Brown and Harrison (1986) studied the effects of a strength training program on the strength and self-concept of two female age groups; young and mature. Forty three subjects participated in a 12-week progressive weight training program, while forty two control subjects maintained their

sedentary lifestyles. The mean age of the mature women and young women for the experimental and control groups combined were 44.4 yrs. and 21.5 yrs respectively. Both the mature and young experimental groups showed significant increases in strength. Gains for the experimental groups ranged from 13 to 31% compared to control group gains which ranged from 0 to 8%. The fact that strength increased in the control group suggests that 1) either strength was not actually measured at the pre-test; 2) some other physical activity during the training period contributed to the increase in strength; 3) a learning effect occured during the training program.

Hunter, Demment, & Miller (1987) examined the strength development during 12 weeks of simultaneous training for both strength and cardiorespiratory endurance. Strength training was initiated for three groups of subjects (Hunter, Demment, & Miller, 1987):

1. The (S group) was untrained subjects that strength trained only.
2. The (ES group) was untrained subjects that strength trained and cardiorespiratory endurance trained.
3. The (TES group) was previously conditioned cardio-respiratory endurance runners but were untrained strength trainers, that both strength and cardio-respiratory endurance trained.

The strength training program consisted of lifting four days/week for 12 weeks and consisted of the following lifts: bench press, seated press, lat. pull down, squat, and leg press. All

exercises were performed with as much resistance as possible for three sets of 7-10 repetitions (i.e. 7RM-10RM). The cardiorespiratory endurance program consisted of running four days/week for 12 weeks at 70% of heart rate reserve.

Endurance training duration increased from 20 minutes the first week to 40 minutes the eighth week. Subject squat lift means significantly increased for all groups (S group = 31 kg.; ES group = 24 kg.; and TES group = 33 kg.). Results of the study indicated that the group that began aerobic and strength training simultaneously was at a disadvantage in strength development. However, the previously aerobically trained group was not at a disadvantage and may have had an advantage in strength development.

White, Yeater, Martin, Rosenberg, Sherwood, Weber, et. al. (1984) examined leg strength in 72 women, ages 50 to 63 years, who were participating in either an aerobic dance or walking program for six months. The dance group performed five aerobic dances, four days/week while the walking group walked two miles/day, four days/week. The women in this study exercise for a mean duration of 33 minutes each session. The mean exercise heart rate for both groups was 116 bpm, approximately 70% of their age predicted maximum heart rate. Isometric knee extension was measured using procedures developed by Clarke (White, et al, 1984). Two maximum contractions were performed and averaged. Isometric strength in right knee extension was measured with the subject seated and the knee flexed to a 115 degree angle. The dancers had a significant increase in knee extension strength of 8.8% (37.5 ± 8.4 lbs. to 40.8 ± 8.1 lbs.). A significant increase of 11.&% in knee extension strength

was also found for the walking group (34.9 $\pm$ 9.8 lbs. to 39.0 $\pm$ 8.7 lbs.). The authors concluded that after six months of participation the improvements found for both the aerobic dance group and the walking group resulted in significant and remarkably similar improvements in the muscular strength of women aged 50-63 years.

No studies have been found in the literature on the changes in leg strength as a result of aerobic bench stepping

Summary

Aerobic dance studies have shown that the amount of energy expended on aerobic dance is adequate to produce a training effect similar to those found in running, swimming and bicycling. Several studies have shown that aerobic dance exercise leads to improvements in oxygen uptake, resting heart rate, and subjects' time on treadmill. They have also shown that the intensity, frequency and duration of exercise are crucial factors which need to be met in order for changes in cardiorespiratory fitness to occur.

Leg strength training studies have shown that leg strength will improve significantly, provided the frequency and duration of the training program follows guidelines typically used in aerobic and strength training programs. The amount of weight lifted should be increased depending upon how many repetitions and sets an individual is able to perform with ease. Subjects who begin strength training simultaneously with cardiorespiratory endurance training, however, may not see changes as large as those subjects who are already endurance training and then begin a strength training program.

Chapter Three

Methods and Procedures

Introduction

This study measured and evaluated selected physiological effects of aerobic bench stepping. Specifically, changes in subjects' maximum oxygen uptake (VO_2 max) in both $ml \cdot kg^{-1} \cdot min^{-1}$ and $L \cdot min^{-1}$, time on treadmill (TOT), body weight (kg), knee flexion strength (lbs) and knee extension strength (lbs) were studied.

Fourteen apparently healthy adult women between the ages 18 and 25 years volunteered to participate in the study. Table 1 presents the subjects' physical characteristics. Most subjects were first or second year college students with a mean age of 20.2 ± 2.08 years. The mean height and weight of 164.8 ± 7.67 cm and 63.0 ± 7.18 kgs indicated that subjects were average height and weight for college women (Hamilton, E.M.N., Whitney, E.N., & Sizer, F.S., 1988). The 26.2 ± 3.90 percent body fat shows that subjects were slightly above average fatness for their age and gender (Golding, et al, 1989).

Table 1

Subjects' Physical Characteristics

Subject	Weight (kg)	Height (cm)	Age (yrs)	% B. Fat
1	61	163	18	23.10
2	54	164	20	23.60
3	76	181	18	28.90
4	61	163	20	28.90
5	63	171	20	26.80
6	62	151	20	30.52
7	65	170	18	22.50
8	60	169	18	25.80
9	60	168	23	24.70
10	60	168	19	21.30
11	72	165	25	30.60
12	52	152	21	18.90
13	76	162	21	30.90
14	52	160	22	29.90
Mean	62.4	164.78	20.21	26.17
SD	7.73	7.63	2.08	3.90

Pre-Test Procedure

1. An informed consent was obtained and signed by each subject (Appendix A).
2. A health and history questionnaire was completed by subjects (Appendix B).

3. Percent body fat was estimated from the Jackson-Pollock (1973) prediction equation for the sum of four skinfolds. The four skinfold sites used in the prediction equation were:

   a. Abdomen - vertical fold immediately to the right of the umbilicus (approximately one inch).

   b. Ilium - a diagonal fold just above the crest of the ilium on the mid axillary line.

   c. Tricep - vertical skinfold taken midway between the acromion and olecranon process on the posterior surface of the arm.

   d. Thigh - vertical skinfold taken midway between the groin line and the patella on the anterior midline of the thigh.

   Prior to the aerobic bench stepping study, a pilot study had been completed on the test-retest reliability of the skinfold measurments at each of the four skinfold sites (Appendix C).

4. Max VO_2 was measured by a graded treadmill test to voluntary exhaustion. The protocol started at a speed of 5.0 mph and a 0% grade. Speed was kept constant throughout the test while grade was increased by 2.5% every two minutes until VO_2 did not increase with an increase in workload, a drop in VO_2 occured, or maximum voluntary exhaustion was reached. Open circuit spirometry gas samples were analyzed every 30 seconds with a Vista integrated metabolic system (Appendix D). Heart rate was monitored with a Vantage watch heart rate monitor (Appendix E). Max VO_2 was defined as the highest per

minute value of oxygen consumption reached during the graded treadmill test.

5. Knee flexion strength was measured using a Bally's Life Fitness computerized weight machine (Appendix F). The subject assumed a sitting position and a padded brace was adjusted over the thigh to limit thigh motion. A padded resistance bar was placed on the distal part of the achilles tendon while the knees were in approximately five degrees of flexion and then the knees were fully flexed against the machine's resistance. Three trials were administered to each subject and averaged to determine strength for knee flexion.
6. Knee extension strength was measured using a Bally's Life Fitness computerized weight machine. The subjects assumed a sitting position with the knees in approximately a ninety degree flexed position. The resistance bar was adjusted to the anterior surface of the ankle and the knees were then fully extended. Three trials were administered to each subject and averaged to determine strength for knee flexion.

Prior to the aerobic bench stepping study, a pilot study was completed on the test-retest reliability of the Bally's Life Fitness computerized weight machine (Appendix G).

Heart Rate

Maximum heart rate was determined by using the formula (220-age). Maximum heart rate was estimated using the above formula instead of using the maximum heart rate found during the

GXT because some subjects may not have attained a true maximum heart rate at the time of the GXT. For consistency between subjects, all subjects used estimated maximum heart rates to determine training intensity.

Subjects measured their own resting heart rates during the third day of class. Maximum heart rate and resting heart rate were used to determine a training heart rate using the Karvonen formula (Karvonen, 1957). Exercise intensity for the aerobic bench stepping portion of the class sessions was prescribed at between 70% and 85% of the heart rate reserve. Heart rate was taken periodically by the subjects during the sessions and used to adjust their intensity to maintain heart rate within their target heart rate zone, approximately 60-85% of max.

Pre-tests were completed by the third session. The aerobic bench stepping conditioning program commenced the fourth session.

The Conditioning Program: Aerobic Bench Stepping

The exercise class was lead by an experienced aerobic instructor. The class met three times a week, approximately 45 minutes each session, for 12 weeks. Class sessions followed a general procedure which included a warm-up, an aerobic bench stepping segment and a cool-down.

The Warm Up (consisted of two segments):

1. A stretching segment consisting of slow static stretches which moved joints through their full range of motion.
2. Brisk movements, such as a fast walk or an easy jog to increase heart rate and blood flow to the muscles.

Muscular Strength and Aerobic Portion:

1. Bench stepping variations were used with and without arm movements The basic aerobic bench stepping movements that were used in the exercise class are described in Appendix H.

2. Subjects maintained intensity, staying above their training threshold as previously determined.

The Cool Down:

A. Slow stepping movements, walking and slow, deliberate stretches.

Specific session procedures including time allocated to warm-up, aerobic bench stepping and cool down is listed in Appendix I.

Post Test Procedure

Tests initially given to each subject were repeated following the 12 week aerobic bench stepping conditioning program. All subjects were retested under as identical conditions to the pretests as possible.

Statistical Treatment of the Data

A multivariate analysis of variance (MANOVA) was selected in this study to determine if a significant difference existed between the pre-test and post-test means for VO2 max, subjects' time on treadmill (TOT), Body Weight, Knee Flexion Strength and Knee Extension Strength. MANOVA was used for two reasons:

1. It provided a single overall test of group differences across all dependent variables at a specified alpha level, effectively controlling type I error rate.

2. It ensured that the linear combination of the dependent variables that produces the most reliable evidence of gross difference was measured (Hair, Anderson, & Tatham, 1987).

Follow-up tests for each dependent variable were used in the event of a significant multivariate F.

Chapter 4

Results and Discussion

Introduction

This chapter presents data to compare the changes in Body Weight (kg), Maximum Oxygen Uptake (VO_2 max) in $ml \cdot kg^{-1} \cdot min^{-1}$ and $L \cdot min^{-1}$, Time on Treadmill (TOT), Knee Flexion Strength (lbs) and Knee Extension Strength (lbs) before and after a 12-week aerobic bench stepping conditioning program. Raw data for VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$), ($L \cdot min^{-1}$), and TOT are presented in appendix J. Raw data for knee flexion strength and knee extension strength are presented in appendix K. The correlation matrix for dependent variables used in this study is presented in Table 2. Data was analyzed with a multivariate analysis of variance (MANOVA) test which indicated that a significant difference existed between the pre & post tests for at least one of the dependent variables ($F_{(7, 7)} = 3.92$, $p < .05$).

Results

A correlation matrix for the six dependent variables was computed to show the intercorrelations between the dependent measures (Table 2). Knee flexion strength and knee extension strength were positively related. As would be expected, the correlation matrix also indicated that VO_2 $ml \cdot kg^{-1} \cdot min^{-1}$, VO_2 $L \cdot min^{-1}$, and body weight were positively related.

Table 2

Inter-Correlations Between Body Weight, VO2 max ($ml \cdot kg^{-1} \cdot min^{-1}$), VO2 max ($L \cdot min^{-1}$), Knee Flexion Strength, Knee Extension Strength and Time on Treadmill.

	1	2	3	4	5	6
1. Wt	1.000 0.0					
2. VO2 $ml \cdot kg^{-1}$	-0.272 0.350	1.000 0.0				
3. Flex	-0.231 0.937	0.218 0.453	1.000 0.0			
4. Ext.	0.232 0.425	0.154 0.600	0.708** 0.005	1.000 0.0		
5. VO2 $L \cdot min^{-1}$	0.610* 0.021	0.583* 0.029	0.170 0.561	0.373 0.189	1.000 0.0	
6. TOT	-0.199 0.496	0.150 0.609	-0.251 0.385	-0.780 0.791	0.008 0.979	1.00 0.0

* significant to 0.05
** significant to 0.01

Body Weight

A small insignificant weight decrease occured (62.42 ± 7.73 kg to 61.85 ± 7.07 kg). There was no evidence that indicated the

treatment caused the difference in subjects' weight ($F_{(1, 13)} = 1.51$, $p > .05$). Changes in subjects' weight (kg) are presented in Table 3.

Table 3

Changes in Subjects' Body Weight Following a 12 Week Aerobic Bench Stepping Conditioning Program.

	Body Weight		
Subject	Pre Test (kg)	Post Test (kg)	Difference
1	61	60	1
2	54	55	- 1
3	76	72	4
4	61	58	3
5	63	64	- 1
6	62	61	1
7	65	67	- 2
8	60	61	- 1
9	60	58	2
10	60	61	- 1
11	72	70	2
12	52	52	0
13	76	75	1
14	52	52	0
Mean	62.42	61.85	0.57
SD	7.73	7.07	1.74

A change in body weight would signifcantly affect oxygen uptake in $ml \cdot kg^{-1} \cdot min^{-1}$. The lack of body weight change was similar to other aerobic dance training studies that met three days per week with comparable intensity and duration (Rockefeller and Burke, 1979; Johnson, Berg, & Latin, 1984; Dowdy, et al., 1985).

Other conditioning studies on women using activities with similar intensity, duration, and frequency produced no weight changes (Eisenman & Golding, 1975; Moody, Wilmore, Girandola, & Royce, 1972; Dowdy, 1985).

Maximum Oxygen Uptake

An increase in subjects' VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$) from 37.83 $\pm$ 4.27 to 39.72 $\pm$ 4.39 was measured. This was statistically significant ($F_{(1, 13)} = 6.54$, $p < .05$). VO_2 max values ($ml \cdot kg^{-1} \cdot min^{-1}$) are presented in Table 4.

Since body weight did not change the increase in VO_2 max ($L \cdot min^{-1}$) would be expected (2.34 $\pm$ 0.35 to 2.49 $\pm$ 0.32). VO_2 max ($L \cdot min^{-1}$) was statistically significant ($F_{(1, 13)} = 6.01$, $p < .05$). Changes in VO_2 max ($L \cdot min^{-1}$) are presented in Table 5.

The significant increases in VO_2 max is supported in similar studies involving aerobic dance training programs (Cearly, 1984; Dowdy, 1985; McCord, 1989; and Watterson, 1984). However, past studies (Vaccaro and Clinton, 1981; Dowdy, 1985; Johnson, 1984; and Eickhoff, Thorland, & Ansorge, 1983) have used univariate tests to determine significance. It was assumed that the variables in the past studies would have been correlated in a multivariate analysis.

Table 4

Changes in VO2 max ($ml \cdot kg^{-1} \cdot min^{-1}$) Following a 12 Week Aerobic Bench Stepping Conditioning Program.

	VO2 max ($ml \cdot kg^{-1} \cdot min^{-1}$)		
Subject	Pre VO2 max	Post VO2 max	Difference
1	40.25	42.79	2.54
2	43.07	47.89	4.82
3	35.17	38.48	0.31
4	38.16	43.79	5.63
5	34.42	37.03	2.61
6	33.70	36.34	2.64
7	47.63	43.10	-4.53
8	42.27	45.00	2.73
9	34.01	37.59	3.58
10	33.11	32.04	-1.07
11	34.44	37.55	3.11
12	39.20	42.00	2.80
13	36.32	36.37	0.05
14	37.87	36.06	-1.81
Mean	37.83	39.72	1.67
SD	4.21	4.39	2.76

Variables in the present study such as VO2, TOT and body weight were found to be correlated, as shown by the correlation matrix (Table 2).

The intercorrelations found between variables indicated a multivariate analysis of variance (MANOVA) should have been used

Table 5

Changes in Subjects' VO_2 max ($L \cdot min^{-1}$) Following a 12 Week Aerobic Bench Stepping Conditioning Program.

	VO_2 max ($L \cdot min^{-1}$)		
Subject	Pre Test	Post Test	Difference
1	2.46	2.57	.11
2	2.33	2.63	.30
3	2.67	2.77	.10
4	2.33	2.54	.21
5	2.17	2.37	.20
6	1.89	2.22	.33
7	3.10	2.89	- .21
8	2.54	2.74	.20
9	2.04	2.81	.77
10	1.99	1.95	- .04
11	2.48	2.63	.15
12	2.04	2.18	.14
13	2.76	2.73	- .03
14	1.97	1.88	- .09
Mean	2.34	2.49	.153
SD	0.35	0.32	.233

instead of a univariate test to determine significance.

The univariate follow-up to the significant MANOVA showed significant increases in both VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$) and VO_2 max ($L \cdot min^{-1}$). Since no significant change in body weight was found, the discussion will concentrate on VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$). Although the increase in VO_2 max is in agreement with recent aerobic dance

studies that used similar frequency, intensity and duration, the present measure is lower. The present study had a 5% increase in VO_2 max $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ and was not as large as increases found by Cearly (10.7%), Johnson (11.1% and 9.31%) and Dowdy (10%).

This smaller increase in VO_2 max may be because the subjects' initial mean VO_2 max $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ was slightly higher than mean values measured in other studies. A larger change in VO_2 would be expected if subjects' mean fitness level was lower prior to the study.

Improvements in VO_2 max with aerobic conditioning are known to be directly related to the type, intensity, duration, and frequency of conditioning as well as the initial fitness level (Dowdy, 1985). The type, intensity, duration and frequency of the aerobic bench stepping used for this conditioning program were very similar to those used in aerobic dance conditioning studies by Milburn and Butts (1983), Rockefeller and Burke (1979), Cearly (1984) and Vaccaro and Clinton, (1981). The results of this study suggest that aerobic bench stepping 45 minutes per day, three days per week for 12 weeks is an adequate form of aerobic activity to improve cardiorespiratory conditioning.

Subjects' Time on Treadmill (TOT)

Mean TOT showed a 9% improvement with an increase from 6.85 $\pm$ 1.83 minutes to 7.46 $\pm$ 1.54 minutes. However, the difference was not significant.($F_{(1, 13)} = 3.04$, $p > .05$). Changes in subjects' time on the treadmill are presented in Table 6.

Table 6

Changes in Subjects' Time on Treadmill (TOT) Following a 12 Week Aerobic Bench Stepping Conditioning Program.

	GXT Time (minutes)		
Subject	1st Time	2 nd Time	Difference
1	7.00	6.50	-.50
2	5.50	5.00	-.50
3	10.00	9.00	-.10
4	5.00	5.00	0
5	7.50	8.50	1.0
6	4.50	5.50	1.0
7	8.00	8.00	0
8	7.00	7.00	0
9	8.00	8.50	.50
10	6.00	8.50	2.5
11	5.50	6.50	1.0
12	9.00	9.00	0
13	4.00	8.00	4.0
14	9.00	9.50	.50
Mean	6.85	7.46	.671
SD	1.83	1.54	1.23

A significant increase in subjects' time on treadmill (TOT) has been reported by current aerobic dance researchers (Dowdy, 1985; Johnson, 1984). Dowdy found that aerobic dancers increased TOT by 21% while joggers increased 14% after a training study of similar

intensity, frequency and duration. Johnson (1984) found that significant changes were established at the 0.01 level as the group that met three times per week increased their TOT by 18%.

The nonsignificant increase in TOT may have occured within the subject sample itself. Some of the subjects may not have pushed themselves during the as hard post test as they had during the pre test. This would account for the same times or the decrease in times reported by half of the subjects. An average for three pre tests and three post tests would have more accurately measured subjects' TOT and would have decreased the possible error in TOT measurement.

Knee Flexion Strength

Knee flexion strength increased from 50.61 ± 7.33 lbs. to 51.01 ± 5.79 lbs, but was not statistically significant ($F_{(1, 13)} = 0.04$, $p > .05$). Pre and post test knee flexion strength data is presented in Table 7

Knee Extension Strength

Knee extension strength improved sinificantly during the 12 weeks (70.6 ± 12.19 lbs. to 77.83 ± 8.21 lbs). The change was significant at the 0.01 level ($F_{(1, 13)} = 12.77$, $p < .01$). Pre and post knee extension strength data is presented in Table 8.

The seven pound increase in knee extension strength can be attributed to bench stepping. Stepping up repeatedly on the bench utilized the large muscle extensors in the anterior thigh, mainly the

Table 7

Changes in Subjects' Knee Flexion Strength Following a 12 Week Aerobic Bench Stepping Conditioning Program.

	Knee Flexion Strength (lbs)		
Subject	Pre Test	Post Test	Difference
1	38.00	52.70	14.7
2	53.00	51.30	- 1.7
3	42.70	53.00	10.3
4	49.30	48.00	- 1.3
5	40.30	46.30	6.0
6	46.70	41.50	- 5.2
7	55.00	45.70	- 9.3
8	64.30	52.00	- 12.3
9	52.30	54.30	2.0
10	57.00	62.70	5.7
11	59.70	57.30	- 2.4
12	51.30	52.30	1.0
13	52.00	54.70	2.7
14	47.00	42.30	- 4.7
Mean	50.61	51.01	.393
SD	7.33	5.79	7.33

knee extensor muscles (quadriceps) and the hip extensors Hip extensors however, were not measured in the present study.

The significant increase in knee extension strength is in agreement with muscular strength, aerobic dance, and walking conditioning programs using similar frequency and duration, and

Table 8

Changes in Subjects' Knee Extension Strength Following a 12 Week Aerobic Bench Stepping Conditioning Program.

	Knee Extension Strength (lbs)		
Subject	Pre Test	Post Test	Difference
1	56.30	77.70	21.4
2	63.00	75.30	12.3
3	65.00	85.00	20.0
4	78.70	78.30	- .4
5	70.70	80.00	9.3
6	54.70	70.00	15.3
7	82.00	80.30	- 1.7
8	89.70	89.00	- .7
9	80.00	81.30	1.3
10	74.70	78.70	4.0
11	85.30	89.70	4.4
12	71.70	75.70	4.0
13	68.30	71.30	3.0
14	48.30	57.30	9.0
Mean	70.60	77.83	7.23
SD	12.19	8.21	7.57

have studied leg strength changes. (White, et al., 1984; Hunter, Demment, & Miller, 1987) After training for approximately the same frequency and duration as subjects in the strength and aerobic endurance training group, which were simultaneously initiated by Hunter, it may be concluded that women in the present study may

have seen a larger strength gain in knee extension strength if they had been participating in an aerobic conditioning program prior to the study.

Although muscular leg strength increases were found in older women, the main purpose of the investigation by White (1984) was to determine the effectiveness of two forms of aerobic training in improving muscular strength. The present study is in agreement with the evidence found by White (1984), as results indicated muscular leg strength gains occured with aerobic bench stepping.

Table 9 presents a summary of all the dependent variables' pre and post test means, differences, F values, and significance level if significance was found.

Table 9

Summary Table for Pre and Post Means, Differences, F Values, and Significance.

Variable	Pre Test X	Post Test X	Difference	F	Pr > F
TOT (min)	6.86	7.46	1.40	3.04	0.01050
Flex (lbs)	50.61	51.01	0.40	0.04	0.8441
Ext. (lbs)	70.60	77.83	7.23	12.77	0.0034**
B.Wt. (kg)	62.42	61.85	-.57	1.51	0.2413
VO2 (ml·kg)	37.83	39.72	1.89	6.54	0.0239*
VO2 (L· min)	2.34	2.49	.15	6.01	0.0291*

* $p < .05$

** $p < .01$

Chapter 5

Summary and Conclusions

Summary

The purpose of this study was to measure maximum oxygen uptake (VO_2 max), time on treadmill (TOT), knee flexion strength and knee extension strength. Subjects participated in a 12-week aerobic bench stepping conditioning program, that met three days/week, for 45 minutes each session

Fourteen females with a mean age of 20.2 years, a mean weight of 63.0 kgs and a mean percent body fat of 26.2% were subjects for the study. Subjects were measured before and after the 12-week aerobic conditioning program. The program included an 8-12 minute warm up, a 15-30 minute aerobic portion, and a 7-12 minute cool down. During the aerobic portion, subjects' heart rate was approximately 70-85% of heart rate reserve.

Changes in VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$), VO_2 max ($L \cdot min^{-1}$), TOT (min), body weight (kg), knee extension strength (lbs.), and knee flexion strength (lbs.) were statistically analyzed using a multivariate (MANOVA) test with univariate within-subject follow-up tests. Changes in body weight (kg), TOT and knee flexion were not significant. Significant changes were found in VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$), VO_2 max ($L \cdot min^{-1}$). The repeated stepping up on the benches also resulted in significant changes in knee extension strength.

Conclusions

Previous studies have shown that aerobic dance training programs may increase cardiorespiratory fitness (Cearly, 1984; Watterson, 1984; Dowdy, 1985). This study suggests that aerobic bench stepping stressed the cardiorespiratory system and muscles in the lower extremities. Improvement was found in both maximum oxygen uptake and knee extension strength. This study measured the changes that resulted from a 12 week aerobic bench stepping conditioning program and supports the following conclusions:

1. The change in cardiorespiratory fitness level as shown by the increase in the amount of oxygen utilized by VO_2 max was significant. This improvement indicated that college women may improve their cardiorespiratory fitness by participating in an aerobic bench stepping conditioning program.

2. Body weight did not change significantly as a result of the 12 week aerobic bench stepping program.

3. Knee extension strength (quadriceps) showed a significant increase from pre to post test measurements. The increase indicated that quadricep strength would improve in college women as a result of the additional repeated stepping movements used in the aerobic bench stepping conditioning program.

Recommendations

Based on the results and observations of the aerobic bench stepping conditioning program, the following recommendations are suggested for further research:

1. An increase in VO_2 max was found for both $ml \cdot kg^{-1} \cdot min^{-1}$ and $L \cdot min^{-1}$ and indicated cardiorespiratory fitness improvement. Specific times during the GXT should also be measured to determine if a greater percent increase in oxygen uptake is seen prior to reaching maximum oxygen uptake.

2. A training study should examine the effects of an aerobic bench stepping training program on fit and unfit individuals, to determine the effects of aerobic bench stepping on each population.

3. Mean VO_2 values and heart rates should be examined for specific aerobic bench stepping moves, to determine intensities for various aerobic bench moves.

4. A control group should be used in other aerobic bench stepping training studies to use as a control for determining differences between the population not participating in an aerobic bench stepping conditioning program and the population that is participating in an aerobic bench stepping conditioning program.

5. Ankle flexion and extension strength, as well as hip flexion and extension strength should also be measured in an aerobic bench stepping conditioning study. The movements for the additional muscular leg strength measurements are also performed repeatedly throughout the aerobic bench sessions.

6. Muscular endurance should be measured along with muscular strength. The endurance measurement is more appropriate seeing that bench stepping uses repeated stepping movements. A more significant change may have been found in muscular endurance than in muscular strength after the 12 week aerobic bench stepping program.

Appendix A

Consent to Participate In Experimental Research Study
University of Nevada, Las Vegas
Exercise Physiology Laboratory

Title of Study: The Effect of Aerobic Bench Stepping on Cardiovascular Fitness and Leg Strength.

Purpose: You are being asked to participate in a research study. We hope to document how aerobic bench stepping 3 times a week effects cardiovascular fitness, body composition and leg strength.

Subjects: College students recruited from an experimental aerobic conditioning activity class.

Procedures: If you decide to volunteer, you will have the following tests administered to you:

Graded Exercise Test - to max
Skin fold measurements - women 4 sites, men 3 sites
Leg strength- hip extension and flexion, knee extension and flexion

Testing will take place during the first two weeks and again the last three weeks of class. After being tested, you will participate in a 3x/week exercise program lasting approximately 50 minutes/day. The daily routine will include approximately 5-10 minutes warm-up, 20-35 minutes aerobic stepping, and 5-7 minutes cool-down. The program will start out easily, progressing to longer aerobic portions as students become familiar with step work and in their ability to step longer.

Risks: The history questionnaire and fitness evaluation attempt to define or contraindications. While testing or exercising there is always a risk of tripping or falling. Muscle soreness and stiffness usually occurs in beginning exercisers. Overexertion can result in nausea and/or fainting. Every effort will be made to monitor exercise intensity and to provide safe leadership and supervision, and to safeguard your health.

Benefits: There are obvious benefits to this research. The data will document the value of exercising and participating in physical activity. Exercising a minimum of three times a week for at least fifteen to twenty minutes are the necessary criteria for improving physical fitness.

In signing this consent form you indicate that you have read the above and understand what is expected of you. Any questions questions you have regarding testing and procedure have been answered to your satisfaction and you enter the program voluntarily. You may at any time withdraw from the testing.

______________________ ______________________ / ________

Subject's Name Printed Subject's Signature Date

______________________ ______________________ / ________

Witness' Name Printed Witness' Signature Date

Appendix B

Personal History Questionnaire
Experimental Bench Stepping Class

Name: ____________________________ Age: ______

General Information:

Why did you sign up for this class?

What goals would you like to achieve by taking this class?

Do you exercise on a regular basis?(3 or more times per week)

What is your favorite activity?

Have you taken any aerobic training classes before? If so, when?

This is an experimental class; your attendance is very important. Will you be able to maintain attendance regularly through out the semester? (m-w-f)

Health Screening Information:

1. Height: ________ ft. _____ inches
2. Weight: ________ lbs. Do you think yourself: (check one)

___ Underweight ___ Normal ___ 5-15 lbs Overweight ___ More than 15 lbs

3. Do you have high blood pressure? Yes / No (circle one)

4. Do you currently smoke? Yes / No

5. Are you a former smoker? Yes / No If yes, when did you quit?

6. Do you have diabetes? Yes / No

7. Have you ever had chest pains while exercising? Yes / No
If yes, please explain:

8. Has any one in your family had a heart attack? Yes / No
If yes, please explain:

9. Do you have asthma? Yes / No

10. Do you have any serious arthritis or orthopedic problems that could prevent you from exercising? Yes / No If yes, please explain:

11. Do you have any reason to believe that exercising may cause you problems at any time during the semester?
Yes / No If yes, please explain:

Is there anything else you feel we should know about your medical history that may hinder your ability to participate in the experimental bench stepping class? If yes, please explain:

Appendix C

Skin Fold Pilot Study

Measurements were taken on 15 subjects using the Harpenden skinfold calipers. Tester used proper technique for each site. Testor measured two times at each site; if there was a large difference, a third measurement was taken. Measurements were recorded. Two days after original skinfold measurements were taken, the tester repeated measurements on the same fifteen subjects. A test-retest reliability coefficient was determined for each site using the Pearson Product Moment Correlation (.96).

Appendix D

VISTA METABOLIC SYSTEM

I. System includes:

Gas analyzers and flow meters
Oxygen and carbon dioxide read outs
Computer- hard drive and floppy disks
CRT- screen
Printer

(See instruction manual for system requirements and installation.)

II. Software: Turbofit

III. Sytem Set-up:

A. set window
B. choose parameters for printed report
C. set plot limits for parameters
D. Warm up gas analyzers at least 20 minutes before use.
E. Change dririte.
F. Adjust flow meters to appropriate location between red marks.
G. Turn on computer and screen. Follow instructions on screen.

IV. Calibration:

A. Volume Calibration Verification - select volume calibration to calibrate the flow meter. See manual for specific calibration procedure.
B. Gas Calibration - cal gas should be in the physiologic range of the subjects you are testing (ie. oxygen concentrations of 14 to 17% and carbon dioxide concentrations of 4 to 7%). See manual for specific calibration procedure.
C. Humidity - enter humidity manually, type in 100% if measuring expired gases.
D. Temperature/Barometric Pressure - enter values manually at the time of testing.
E. Save calibrations.

V. Perform Test:

Leave protocol on. Enter subject data (ID number, height, weight, age.) Begin sampling. Start test at same time treadmill protocol is started.

VI. Print Report:

No graphic printout; parameter data only.

Appendix E

Validity of the Polar Vantage Heart Rate Monitor

Studies have found that the Polar Vantage XL heart rate monitor, although quite susceptible to rapid changes in heart rate, was an accurate estimate of heart rate. A study by Godsen, 1991, compared heart rate data collected with Polar heart rate monitors to actual heart rate as measured by an EKG. The Polar Vantage heart rate monitors yielded exercise values within ± 6 bpm approximately 95% of the time. In a similar study, by Carroll, et al., 1991, the Polar heart rate monitor data was compared to data transfered through computer interface. Carroll's study found that computer and monitor files were exactly the same. Carroll, et al., suggests that the hardware and software components of the Polar Vantage Heart Rate monitor have been engineered to a very high standard.

Appendix F

Bally's Life Fitness Weight Machines

The Bally's Lifefitness weight machines are new, computerized resistance weight machines. The machines are programmable for individualized progressive resistance training and specific resistance loads. The Lifecircuit machines are built to work different muscle groups. The available units include: abdominal, arm curl, tricep extension, back extension, chest press, seated row, leg extension, leg curl, shoulder press, lateral pull down, leg press and a fly machine. The computerized weight machines are positioned in a circuit training-type arrangement that allows the user to go from one mucle group (machine) to the next, staying within the same Lifecircuit system.

Bally's weight machines are programmable for a test mode that enables an individual to determine the maximum resistance they are able to lift. The concept is to determine an individual's maximum resistance and then to work at a certain percentage of that maximum. This concept is similar to the 1-RM or 1 repetition maximum. The test mode was utilized in the present study to determine maximum leg strength for knee flexion and knee extension.

Appendix G

Bally's Life Fitness Computerized Weight Machine
Test - Retest Reliablity

Prior to the beginning of the aerobic bench stepping study, a pilot was completed for the test-retest reliability of leg strength measurement. Knee flexion strength and knee extension strength were measured. Measurements were taken on 10 subjects. Tester placed subjects in correct settings for seat height and axis placement. Subjects were given two tests on each machine; if a difference of 5 lbs or more (>5 lbs) was seen, a third test was given. Two days after original leg strength measurements were taken, the same 10 subjects repeated the tests.

A test - retest reliability coefficient was determined for each machine using a Pearson Product Moment Correlation Coefficient. The correlation coefficient for knee flexion strength and knee extension strength was 0.99 and 0.98 respectively.

Appendix H

Basic Bench Stepping Moves

Front step- normal stepping motion.

Front step heel to buttocks- normal stepping motion, heel of second foot raises back towards buttocks instead of landing on step.

Front step leg raise- normal stepping motion, straight leg raise to the side instead of landing on step.

Front step knee up- normal stepping motion, knee of second leg raises up towards chest instead of landing on step.

Side over side- body is parallel to bench, step to middle of bench, both feet on top of bench, then step down on opposite side the move started from, with the same foot that started move.

Side step heel to buttocks- body is parallel to bench, first leg steps to top of bench, heel of second foot raises back towards buttocks instead of landing on step.

Side step leg raise- body is parallel to bench, first leg steps to top of bench, second leg stays straight and raises to the side instead of landing on step.

Side step knee up- body is parallel to bench, first leg steps to top of bench, knee of second leg raises up towards chest instead of landing on step.

Side step turn- body is parallel to bench, leg nearest to bench steps up, turn on top of bench and land with same leg that started move.

Side straddle step- from the top of the bench, stepping down to each side in a straddle-type movement.

Straddle lunge- start on top of bench, leg steps off bench wide, deep knee bend then back to top of bench.

Appendix I

Specific Session Time Allotment

Sessions 4-6: 10 minutes warm-up (stretches). Benches were not available; 20 minutes brisk walk/jog around a quarter mile track. 10 minutes half sit-ups and push-ups. 5 minutes cool-down (stretches). 45 minutes total.

Sessions 7-9: 15 minutes warm-up. 20 minutes aerobic bench stepping- introduced basic bench steps, emphasizing correct form and posture. 10 minutes cool-down. 45 minutes total.

Sessions 10-14: 10 minutes warm-up. 25 minutes aerobic bench stepping. 10 minutes cool-down. 45 minutes total.

Sessions 15-27: 7 minutes warm-up. 30 minutes aerobic bench stepping. 8 minutes cool-down. 45 minutes total.

Appendix J: part 1

Raw Data for GXT (ml·kg^{-1}·min^{-1}) and TOT

	TIME	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
GS	PRE-ML/KG	18.88	20.55	22.43	27.30	26.61	26.50	27.56	31.16	29.68	31.39	32.18	32.57	32.85	34.01	33.88						
	POST-ML/K	18.84	19.48	28.94	29.90	29.30	30.61	31.82	33.43	31.95	35.54	36.16	35.44	37.59	36.84							
KE	PRE-ML/KG	17.45	23.21	28.03	31.28	29.23	31.11	33.94	32.92	34.41	35.28	37.87	37.74									
	POST-ML/K	13.12	16.26	25.37	27.42	30.92	30.74	31.68	33.40	31.56	36.06	34.27										
TT	PRE-ML/KG	17.19	19.39	29.32	32.98	30.73	32.29	34.44	35.55	35.03	37.15	38.97	41.26	38.04	43.70	42.87	43.59	44.42	45.88	46.86	47.63	40.11
	POST-ML/K	13.53	19.50	25.94	27.47	26.18	29.22	31.31	31.07	30.66	33.99	35.19	35.65	35.35	35.96	38.70	40.71	42.15	43.10	42.16	42.71	
JF	PRE-ML/KG	21.02	22.13	32.45	30.96	32.23	33.14	33.08	33.82	34.39	36.32	35.74										
	POST-ML/K	18.10	19.17	24.04	32.01	31.53	32.88	33.16	34.21	34.06	36.37	28.83										
CD	PRE-ML/KG	17.40	24.84	33.04	31.23	31.70	32.18	36.36	34.06	34.73	36.94	39.12	40.70	39.04	42.00	43.07	35.94					
	POST-ML/K	14.10	19.10	24.49	25.95	31.02	33.61	35.74	33.68	39.69	39.35	41.68	42.38	43.40	44.33	42.68	45.01	47.89	44.55			
LI	PRE-ML/KG	13.27	20.74	27.24	22.95	26.91	27.69	27.59	29.29	30.52	25.45											
	POST-ML/K	15.45	24.79	27.59	30.63	29.89	33.18	32.97	33.74	35.10	34.66	36.34	35.92									
DS	PRE-ML/KG	20.22	24.39	28.44	26.93	28.04	29.41	32.52	31.83	31.83	32.60	36.79	37.62	37.41	38.27	38.15	40.25	39.11				
	POST-ML/K	17.86	21.31	26.71	30.17	31.85	31.24	31.71	32.08	32.03	31.63	36.27	34.51	37.15	39.97	39.58	42.76					
LM	PRE-ML/KG	22.94	24.68	28.26	30.72	28.32	31.31	33.07	36.07	35.10	35.47	36.18	38.75	37.81	39.20							
	POST-ML/K	23.30	37.20	32.80	28.71	32.42	31.74	35.15	34.39	36.39	36.88	37.39	38.71	42.00	40.62							
AB	PRE-ML/KG	20.29	20.93	28.33	30.00	30.18	31.42	31.50	33.80	34.54	34.10	37.78	36.91	38.98	39.57	39.52	42.27	40.60				
	POST-ML/K	18.22	20.65	29.70	31.70	29.74	30.79	33.95	33.92	35.04	35.67	36.71	39.52	37.69	39.36	39.61	43.04	45.00	42.60	44.61		
AF	PRE-ML/KG	18.77	22.21	26.02	27.01	28.49	28.63	30.60	31.25	31.99	34.09	34.68	35.17	35.04								
	POST-ML/K	14.58	20.56	25.51	23.29	24.72	26.84	27.35	26.51	28.71	31.54	29.90	32.40	34.04	34.29	35.11	35.33	38.48				
KL	PRE-ML/KG	24.22	24.09	26.12	29.17	28.65	28.51	32.37	30.92	32.71	32.59	34.42										
	POST-ML/K	22.04	22.85	24.51	27.03	27.98	28.32	33.54	32.89	34.16	34.93	35.47	36.08	37.03								
JW	PRE-ML/KG	17.21	16.84	19.15	18.41	19.87	22.26	21.64	22.51	23.34	24.04	28.35	27.24	29.48	29.30	32.76	30.79	33.11				
	POST-ML/K	16.28	15.90	15.76	19.23	18.30	19.67	21.50	22.94	22.78	24.07	25.85	25.75	28.18	27.66	31.07	31.26	32.04	29.30			
RR	PRE-ML/KG	19.26	23.34	30.66	31.52	33.00	34.16	33.82	34.44	32.33												
	POST-ML/K	16.66	17.69	27.24	28.44	31.18	31.20	32.40	32.35	33.06	33.26	35.88	35.18	35.29	36.63	37.11	37.55					
AS	PRE-ML/KG	17.36	21.01	24.88	25.81	27.92	28.37	31.12	30.34	31.48	31.15	33.18	33.87	34.62	33.72	36.88	38.15	38.02	38.16	33.19		
	POST-ML/K	16.17	20.31	24.27	26.08	27.27	27.99	32.54	33.63	34.89	35.77	36.04	36.90	37.79	38.62	39.91	40.95	42.01	42.86	43.13	43.79	

Appendix J: part 2

Raw Data for GXT ($L \cdot min^{-1}$) and TOT

	TIME	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
GS	PRE-L/M	1.13	1.23	1.35	1.64	1.60	1.59	1.65	1.87	1.78	1.88	1.93	1.95	1.97	2.04	2.03						
	POST-L/M	1.09	1.13	1.68	1.73	1.70	1.78	1.85	1.94	1.85	2.06	2.10	2.06	2.18	2.14							
KE	PRE-L/M	0.91	1.21	1.46	1.63	1.52	1.62	1.77	1.71	1.79	1.83	1.97	1.96									
	POST-LM	0.68	0.85	1.32	1.43	1.61	1.60	1.65	1.74	1.64	1.88	1.78										
TT	PRE-L/M	1.12	1.26	1.91	2.14	2.00	2.10	2.24	2.31	2.28	2.41	2.53	2.68	2.47	2.84	2.79	2.83	2.89	2.98	3.05	3.10	2.61
	POST-L/M	0.91	1.31	1.74	1.84	1.75	1.96	2.10	2.08	2.05	2.28	2.36	2.39	2.37	2.41	2.59	2.73	2.82	2.89	2.82	2.86	
JF	PRE-L/M	1.60	1.68	2.47	2.35	2.45	2.52	2.51	2.57	2.61	2.76	2.72										
	POST-L/M	1.36	1.44	1.80	2.40	2.36	2.47	2.49	2.57	2.55	2.73	2.16										
CD	PRE-L/M	0.94	1.34	1.78	1.69	1.71	1.74	1.96	1.84	1.88	1.99	2.11	2.20	2.11	2.27	2.33	1.94					
	POST-L/M	1.05	1.35	1.43	1.63	1.71	1.85	1.97	1.85	2.18	2.16	2.29	2.33	2.39	2.44	2.35	2.48	2.63	2.45			
LI	PRE-L/M	0.82	1.29	1.69	1.42	1.67	1.72	1.71	1.82	1.89	1.58											
	POST-L/M	0.94	1.51	1.68	1.87	1.82	2.02	2.01	2.06	2.14	2.11	2.22	2.19									
DS	PRE-L/M	1.23	1.49	1.73	1.64	1.71	1.79	1.98	1.94	1.94	1.99	2.24	2.30	2.28	2.33	2.33	2.46	2.39				
	POST-L/M	1.07	1.28	1.60	1.81	1.91	1.87	1.90	1.92	1.92	1.90	2.18	2.07	2.23	2.40	2.37	2.57					
LM	PRE-L/M	1.19	1.28	1.47	1.60	1.47	1.63	1.72	1.91	1.83	1.84	1.88	2.01	1.97	2.04							
	POST-L/M	0.76	1.21	1.41	1.71	1.50	1.69	1.65	1.83	1.79	1.89	1.92	1.94	2.01	2.18							
AB	PRE-L/M	1.22	1.26	1.70	1.80	1.81	1.89	1.89	2.03	2.07	2.05	2.27	2.21	2.34	2.37	2.37	2.54	2.44				
	POST-L/M	1.11	1.26	1.81	1.93	1.81	1.88	2.07	2.07	2.14	2.18	2.24	2.41	2.30	2.40	2.42	2.63	2.74	2.60	2.72		
AF	PRE-L/M	1.43	1.69	1.98	2.05	2.17	2.18	2.33	2.37	2.43	2.59	2.64	2.67	2.66								
	POST-L/M	1.05	1.48	1.84	1.68	1.78	1.93	1.97	1.91	2.07	2.27	2.15	2.33	2.45	2.47	2.53	2.54	2.77				
KL	PRE-L/M	1.53	1.52	1.65	1.84	1.80	1.80	2.04	1.95	2.06	2.05	2.17										
	POST-L/M	1.41	1.46	1.56	1.73	1.79	1.81	2.14	2.10	2.18	2.23	2.27	2.30	2.36								
JW	PRE-L/M	1.03	1.01	1.15	1.10	1.19	1.34	1.30	1.35	1.40	1.44	1.70	1.63	1.77	1.76	1.97	1.85	1.99				
	POST-L/M	0.99	0.97	0.96	1.17	1.12	1.20	1.31	1.40	1.37	1.47	1.58	1.57	1.72	1.69	1.90	1.91	1.95	1.79			
PR	PRE-L/M	1.39	1.68	2.21	2.27	2.38	2.46	2.43	2.48	2.36												
	POST-L/M	1.17	1.24	1.91	1.99	2.18	2.18	2.27	2.26	2.31	2.33	2.51	2.46	2.47	2.56	2.60	2.63					
AS	PRE-L/M	1.06	1.28	1.52	1.57	1.7	1.73	1.9	1.85	1.92	1.9	2.02	2.07	2.11	2.06	2.25	2.21	2.32	2.33	2.02		
	POST-L/M	0.94	1.18	1.41	1.51	1.58	1.62	1.87	1.95	2.02	2.07	2.09	2.14	2.19	2.23	2.31	2.37	2.43	2.48	2.5	2.54	

Appendix K
Raw Data for Knee Flexion and Extension Strength

	Extension Pre-Test				Extension Post Test				Flexion Pre-Test				Flexion Post Test			
Subject	Trial 1	Trial 2	Trial 3	Pre X	Trial 1	Trial 2	Trial 3	Post X	Trial 1	Trial 2	Trial 3	Pre X	Trial 1	Trial 2	Trial 3	Post X
1	59	62	68	63.00	74	75	77	75.30	53	54	52	53.00	52	53	49	51.30
2	52	53	64	56.30	79	82	72	77.70	31	36	47	38.00	55	53	50	52.70
3	53	42	50	48.30	52	57	63	57.30	50	49	42	47.00	41	37	49	42.30
4	77	79	80	78.70	80	76	79	78.30	50	54	44	49.30	49	48	48	48.00
5	51	53	60	54.70	76	68	66	70.00	40	46	54	46.70	40	43	52	41.50
6	50	80	82	70.70	79	79	82	80.00	39	40	42	40.30	45	44	50	46.30
7	65	67	63	65.00	85	85	85	85.00	43	45	40	42.70	51	51	57	53.00
8	82	81	77	80.00	82	78	82	81.30	52	49	56	52.30	55	53	55	54.30
9	82	81	77	80.00	82	78	82	81.30	52	49	56	52.30	55	53	55	54.30
10	86	85	98	89.70	89	91	87	89.00	67	66	60	64.30	47	56	53	52.00
11	85	83	88	85.30	84	90	95	89.70	58	60	61	59.70	60	56	56	57.30
12	63	72	80	71.70	71	75	81	75.70	47	51	56	51.30	48	52	57	52.30
13	66	75	83	74.70	82	75	79	78.70	59	55	57	57.00	63	60	65	62.70
14	72	80	94	82.00	81	76	84	80.30	47	60	58	55.00	45	47	45	45.70

Appendix L
Raw Data for Bally's Lifefitness Pilot Study

Subject	Ex: Trial 1a	Ex: Trial 1b	Ex: Trial 1c	Exten. X	Ex: Trial 2a	Ex: Trial 2b	Ex: Trial 2c	Exten. X	Extension
1	70.00	66.00	69.00	68.30	69.00	65.00	64.00	66.00	Correlation
2	78.00	82.00	82.00	80.67	76.00	77.00	77.00	76.70	0.98
3	75.00	76.00	73.00	74.70	72.00	79.00	78.00	76.30	
4	71.00	78.00	79.00	76.00	82.00	83.00	82.00	82.30	
5	72.00	71.00	71.00	71.30	71.00	74.00	71.00	72.00	
6	93.00	97.00	98.00	96.00	96.00	97.00	98.00	97.00	
7	77.00	73.00	75.00	77.00	74.00	76.00	79.00	76.30	
8	73.00	77.00	78.00	76.00	76.00	78.00	77.00	77.00	
9	74.00	63.00	73.00	70.00	77.00	87.00	86.00	83.30	
10	73.00	75.00	75.00	74.30	81.00	77.00	76.00	78.00	
Subject	Fl: Trial 1a	Fl: Trial 1b	Fl: Trial 1c	Flex. X	Fl: Trial 2a	Fl: Trial 2b	Fl: Trial 2c	Flex. X	Flexion
1	49.00	39.00	35.00	41.00	44.00	44.00	45.00	44.30	Correlation
2	41.00	44.00	39.00	42.00	39.00	41.00	39.00	40.00	0.99
3	64.00	69.00	70.00	67.70	74.00	67.00	73.00	71.30	
4	45.00	48.00	50.00	47.70	47.00	55.00	55.00	52.30	
5	50.00	51.00	48.00	49.70	55.00	55.00	55.00	55.00	
6	97.00	96.00	94.00	95.70	94.00	98.00	97.00	96.30	
7	53.00	49.00	44.00	48.70	51.00	47.00	46.00	48.00	
8	57.00	56.00	54.00	55.70	54.00	58.00	57.00	56.30	
9	48.00	55.00	56.00	53.00	53.00	55.00	56.00	54.70	
10	55.00	53.00	58.00	55.30	57.00	52.00	55.00	54.70	

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