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Improving Muscular Strength And Balance In An Older Active Population

Jon Bradley Campbell
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IMPROVING MUSCULAR STRENGTH AND BALANCE IN AN OLDER, ACTIVE POPULATION

CAMPBELL

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IMPROVING MUSCULAR STRENGTH AND BALANCE IN AN OLDER, ACTIVE POPULATION

(TITLE)

BY

JON BRADLEY CAMPBELL

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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YEAR

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ABSTRACT

IMPROVING MUSCULAR STRENGTH AND BALANCE IN AN OLDER, ACTIVE POPULATION

Jon Bradley Campbell

The purpose of this study was to determine the effects of three weekly strength and balance routines on selected muscular strength and balance parameters on an older (ages 60-88 years), active population of men and women.

Twenty-two, men and women, members of the EIU Adult Fitness Program volunteered to participate in the study which was conducted over a ten week period of time. An additional five individuals acted as exercise controls.

Prior to training, and directly after the ten week period, selected muscular strength and balance tests were administered. These tests consisted of: Static Balance (stabilometer, stork stands with the eyes open and closed), Dynamic Balance (Modified Bass test), Foot Extension Strength (cable tensiometer), Lower Leg Isometric Strength (cable tensiometer), Maximal Isotonic Leg Extension Strength (Universal leg extension machine).

Each of the 30 training sessions consisted of three leg strength exercises (chair squats, wall squats, and heel raises) and were interspersed with two balance exercises (one-legged stork stands with the eyes open and closed, and a heel-to-toe walk). Initial starting points were determined from pretesting results and progressions were made by either increasing the number of sets or repetitions.

Dependent _t_-tests were used to determine if the changes between the

pre and post training test data were significant. The .05 level of confidence was used to denote statistically significant differences.

Results indicated that there was a statistically significant improvement for all 11 muscular strength and balance measures in the experimental group and no statistically significant improvements were seen in the control group. Group mean comparisons showed that improvements made by the experimental group were statistically significantly better as compared to the control group in four of the parameters measured: stork stand eyes open - left foot, foot extension strength - right and left feet, and maximal isotonic leg extension strength.

Conclusions drawn from this study are that after performing a ten week, three sessions per week training program, that some muscle strength and balance parameters can be significantly improved in an older (ages 60-88 years), active population of men and women. This study also demonstrates that a simple ten-12 minute routine, that could conceivably be performed at home, can have beneficial effects in older, active men and women. These effects in combination with other factors might help reduce the risk of falling.

DEDICATION

This paper is dedicated to my family. Throughout my life they have instilled in me the thought that I can do anything if I put my mind to it and work hard enough for it. I dedicate this paper to them, I love you all.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to the twenty-seven men and women who volunteered for this study. Without their time, hard work, and dedication this study would not have been possible. The author also wishes to thank: Dr. Mark Kasper, Dr. John Emmett, Mr. Terry Ramsey, Traci Reindle, and my wife, for their time and effort throughout this study. A special thanks to Dr. Thomas Woodall. Without his guidance and support this project would not have been possible.

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CHAPTER I

INTRODUCTION

Background

It has been estimated that by the year 2000, over 30 million Americans (12.5 percent of the population), will be 65 years of age or older (Agre, Pierce, Raab, McAdams, & Smith, 1988). With an increase in age comes a loss of muscle strength and endurance (Larsson, Grimby, & Karlsson, 1979). This loss in muscular strength could be a contributing factor in the decreased ability to perform activities of daily living, decreased mobility, and an increased number of falls in the elderly (Evans, 1992). Increasing attention is being paid to the role of exercise in the well-being and independence of men and women over the age of 65 years.

Increases in muscular strength are not restricted to the young. Recently, researchers have conducted studies to determine whether strength training can improve muscular strength and balance in older adults. Frail, institutionalized elderly men and women have even shown significant muscular strength increases with strength training (Fiatarone, 1990). A review of the literature has found an increase in the number of investigations undertaken to determine how the elderly respond to resistance training.

Many older adults would like to strength train but they either lack the financial resources to join a health club or they feel intimidated by the younger population at such establishments. This study investigated whether muscular strength and balance can be improved by basic exercises that can be performed at home and without the need for expensive equipment.

Purpose of the Study

The purpose of this study was to determine the effects of three weekly strength and balance routines on selected muscular strength and balance measures on an older (ages 60-88 years), active population of men and women.

Null Hypothesis

Muscular strength and balance in an active, elderly population cannot be improved by a balance and a strength training program.

Limitations

The study was limited to 27 apparently healthy, active adults, 60-88 years of age, who were also volunteers from the Eastern Illinois University's Adult Fitness Program.

Assumptions

It was assumed that the participant gave a good effort during each training session and that they provided accurate information concerning any pain or discomfort they experienced. Furthermore, because of the instructions provided, is was assumed that none of the subjects changed their normal routines so as to increase or decrease their physical activity.

Definition of Terms

Active

Those who meet the frequency, intensity, duration, mode, and progression according to the guidelines for exercise testing and prescription (American College of Sports Medicine, 1991).

Dynamic Balance

The ability to maintain equilibrium during vigorous movements (Sharkey, 1990).

Isometric Contraction

Muscle action in which the ends of the muscle are prevented from drawing closer together, with no change in length (Fox, Bowers, & Foss, 1993).

Isotonic Contraction

Contraction in which the muscle shortens with varying tension while lifting a constant load Fox, et al. (1993).

Muscular Endurance

The ability of a muscle or muscle group to perform repeated contractions against a light load for an extended period of time Fox, et al. (1993).

Muscular Strength

The force or tension that a muscle or group of muscles can exertagainst a resistance in one maximal effort Fox, et al. (1993)

Static Balance

The ability to maintain equilibrium without vigorous movements.

CHAPTER II

REVIEW OF RELATED LITERATURE

Strength Training in Elderly Subjects

To achieve a training effect, it is necessary to expose an individual to a stress which produces an overload response (Fox, Bowers, & Foss, 1989). During training, the intensity of the load required to produce an overload response increases as the performance is improved Fox, et al. (1989). Recent studies have clearly demonstrated that older men and women, even up to 96 years of age, maintain their ability to increase their muscle strength (Fiatarone, 1990). However, the reduced activity often seen with advancing age causes changes in skeletal muscle such as decreased insulin sensitivity, mass, strength, endurance, and glycogen content (Bortz, 1982).

This chapter reviews how strength training can decrease atrophy seen with aging and how muscular strength training has been used by various investigators to increase strength and improve postural balance in older populations. The review will be broken down into upper and lower body strength, strength training and its affects on postural balance, and a summary of related information.

Strength conditioning has been defined as training in which the resistance against which a muscle generates force is progressively increased over time (Evans, 1992). Muscle strength has been shown to increase in response to training between 60 and 100 percent of the one repetition maximum effort (Frontera, Hughes, & Evans, 1991). An one repetition maximum

(1 RM) is the maximum amount of weight that can be lifted with one contraction Fox, et al. (1989). Lifting weight requires that a muscle shorten as it produces force. This is called a concentric contraction. Lowering the weight, on the other hand, forces the muscle to lengthen as it produces force. This is an eccentric muscle contraction. Eccentric contractions are what produces structural damage that may stimulate increased muscle protein turnover (Evans, 1992).

Upper-Body Strength

Moritani and deVries (1980) compared elbow flexor strength gains in elderly and young men (70 & 22 years, respectively). Both young and old subjects participated in a strength training program which consisted of progressive resistance dumbbell exercises; 10 repetitions of two-thirds maximum for the elbow flexors twice a day, three times per week for a period of eight weeks. The subjects' dominant elbow flexor muscle groups were trained and their non-dominant muscle groups served as untrained controls. The maximal strength of each subject was tested at two week intervals and the training load was adjusted to maintain the two-thirds maximum threshold suggested for progressive resistance programs.

They concluded that after the eight week muscle training program, there were significant increases in the maximal strength in the trained arms of old men (mean gain of 13.8 lbs, $p < 0.001$) and young men (mean gain of 26.0 lbs, $p < 0.002$), respectively.

A study conducted by Agre and associates (1988) compared strength training with wrist and ankle weights to a more traditional strength training routine. Twenty-nine subjects participated in an organized exercise program for one hour, three days per week, for 25 weeks. The exercise program included approximately ten minutes of warm-up and ten minutes of aerobic exercise at target heart rates of 65 percent of maximal heart rate. This activity was followed by 25 to 30 minutes of strength and flexibility exercises and ten to 15 minutes of cool-down activities. During the sessions the subjects stood in place, sat in chairs, or worked on floor mats. The exercises involved static stretching to increase flexibility followed by strengthening exercises which consisted of slow circling motions of the arms and legs and repetitive movements against gravity such as arm curls and leg lifts. The specific exercise routine varied each day, but all muscle groups tested were included in the strengthening exercise program each day.

They concluded that older women can make significant muscular strength gains in the shoulder girdle, elbow flexors, and elbow extensors with a light resistance exercise program.

The investigators also noticed there was a decrease in joint pain complaints from the subjects. At the onset of the study, 83 percent of the exercising subjects complained of pain in at least one joint. At the end of the study, 59 percent of the individuals with joint pain at the onset had a reduction in pain while only 7 percent complained of an increase in pain.

<u>Lower-Body Strength</u>

Frontera and associates (1988) looked at the effects of strength training on skeletal muscle function and mass. Twelve healthy untrained volunteers (age 60-72 years), participated in a 12-week strength training program (8 repetitions per set, 3 set per day, 3 days per week), at 80 percent of an one repetition maximum (1RM) for the extensors and flexors of both knee joints. They were evaluated before the program and after six and 12 weeks of training. Weekly measurements of an 1 RM showed a progressive increase in extensor and flexor strength. Post-training results showed extensor and flexor strength had increased 107.4 percent ($p < 0.0001$), and 226.7 percent ($p < 0.0001$), respectively. Isokinetic peak torque of the extensors and flexors measured on a Cybex II Dynamometer increased 10.0 and 18.5 percent ($p < 0.05$), at 60 degrees per second and 16.7 and 14.7 percent ($p < 0.05$), at 240 degrees per second. They concluded that the capacity for increasing muscle mass is retained in old age.

Charette and associates (1991) conducted a study to determine if a lower-limb strength training regime would produce strength gains. Twenty-seven healthy women (64-86 years of age) participated in a 12-week resistance training program emphasizing the muscles in the lower body. Seven resistance exercises for the leg and hip were performed three days per week for 12 weeks. Three sets of six repetitions were used for all exercises until the second week when six sets were used for the leg extension and leg press. All exercises were performed on the Universal Spartucus, Marcy Leg Trainer, and Universal Total Hip Trainer. The intensity of the training increased from 65 percent of 1 RM at baseline to 75 percent of 1 RM during the last three weeks. Adjustments in the 1 RM were made during the second and seventh weeks of training. At the conclusion of the study, strength gains increased in all exercises with the largest gain in the leg curl (115 percent) and the smallest in the leg press (28.3 percent), and hip extension (28.3 percent). They concluded that progressive resistance training can increase muscle strength in an older population.

Frontera et al. (1988) conducted their study with just two exercises involving the leg extensors and flexors, whereas Charette et al. (1991), utilized seven exercises: leg press, leg flexion, leg extension, hip abduction, hip adduction, hip flexion, and hip extension. Muscle groups emphasized were: quadriceps group, hamstrings group, gluteus maximus and medius, adductor magnus, and iliopsoas. The conclusion drawn by Charette and associates in comparison to Frontera's data was that elderly women can safely engage in a high-resistance training program consisting of more than two exercises and involving muscle groups beyond the leg extensors and flexors.

Fiatarone and associates et al. (1990) also conducted a study involving the knee extensors in frail, institutionalized persons whose ages averaged 90 years. Muscle strength of the knee extensors (quadriceps femoris), was measured using a standard weight-and-pulley system. An eight week training protocol was used. The initial 1 RM was used to set the load for the first week at 50 percent of the 1 RM. Three times per week the subjects performed three sets of eight repetitions with each leg in six to nine seconds per repetition, with a one to two minute rest period between sets. By the second week, or as tolerated, the load was increased to 80 percent of the 1 RM. The 1 RM was remeasured every two weeks and the training stimulus adjusted to keep the load at 80 percent of the new 1 RM. Gains in muscle strength were found to be highly significant and clinically meaningful in all subjects. The average strength gain at eight weeks was 174 percent (± 31 percent). Comparing the right and left legs, the data showed a 167 percent (± 28 percent) on the right and 180 percent (± 33 percent) on the left, $p < 0.0001$). Absolute weight lifted increased from 8.02 kg to 20.6 kg with the right leg and from 7.6 kg to 19.3 kg with the left leg.

The strength gain was progressive throughout the investigation and did not plateau during the eight weeks of training. There was no statistical difference between the way in which men and women responded to the training.

The investigators concluded that a high-intensity weight-training program is capable of inducing dramatic increases in muscle strength in frail men and women up to 96 years of age. The increase in lower-extremity strength ranged from 61 percent to 374 percent percent over baseline. It was also concluded that perhaps 30 percent to 40 percent of muscle strength is lost over an adult lifespan, and at the end of the training period the subjects were stronger than they had been in years. As a result of participating in the study, two subjects no longer needed walking canes and one subject who could not initially rise from a chair without use of the arms, was able to perform this task.

Liemohn (1975) studied isometric strength in 52 men, ranging in age from 42 to 83 years. He assigned each subject into a group by decade of age. Each group performed a 15-minute exercise session, three days a week, for a period of six weeks. The training program was an exact replication of the strength tests in terms of positions used for muscle contraction, but the contractions were held for a duration of five seconds. A cable tensiometer was used to obtain the measurements for the four strength tests administered. The following strength tests were administered bilaterally in the order listed: knee extension, knee flexion, forearm flexion, and forearm extension. The subjects were given three trials to perform the isometric contraction with a mean of the second and third scores used as a final measure. A control group performed balance, flexibility, and coordination exercises with overload being avoided.

The results showed that the exercising group made statistically significant gains in strength but only for a few exercisers; the oldest group (ages 71 to 80 years) showed no significant gains in strength for any of the eight tests.

Liehomn's findings also show that longer training periods are needed to elicit significant strength gains. The overload principle is also an important factor in gaining muscular strength, and an adequate stimulus is needed to produce a strength gain as indicated by the control group which saw no significant strength gains with no overload involved.

Frontera et al. (1990) examined the effects of weight training on maximum aerobic power and its determinants in 60 to72 year old subjects. The exercise protocol consisted of 12 weeks, eight repetitions per set, three sets per session, and three sessions per week at 80 percent of the 1 RM. The knee extensors and flexors were trained on a Universal Strength Gym. At the conclusion of the study muscle biopsies revealed a mean increase in fiber area of 28 percent and 15 percent increase in the number of capillaries per fiber. The strength training program did not affect arm cycle ergometery VO2 max, HR max, maximal VE during aerobic power testing, hemoglobin concentration, or blood volume. However, the increased concentration of capillaries per fiber may account for the slight but significant improvement in whole body capacity for oxygen utilization during leg cycle VO2 max test.

<u>Balance Changes with Strength Training</u>

Studies have shown decrements in muscle mass, force production per cross-sectional area of muscle, and isokinetic joint moments in several lower extremity muscle groups with usual aging. This weakness may be an important and potentially reversible component of instability during routine daily activities, predisposing the elderly to falls (Judge, Lindsey, Underwood, & Winsemius, 1993).

Cross-sectional studies have used force platforms which record the center of pressure, center of reaction force, to estimate body sway (Shimba, 1984). Older persons have slightly higher measures of sway in double stance when compared to younger subjects (Era & Heikkenen, 1985).

A study conducted in New Zealand assessed the factors associated with falls and if there was any differences between men and women. They followed 761 subjects for one year and recorded 506 falls during that time. Variables associated with an increased risk of falling differed in men and women. In men, decreased levels of physical activity, stroke, arthritis of the knees, impairment of gait, and increased body sway were associated with an increased risk of falls. In women, the total number of drugs, psychotropic drugs and drugs liable to cause postural hypotension, standing systolic blood pressure of less than 110 mm Hg, and evidence of muscle weakness were also associated with an increased risk of falling. The investigators concluded that falls in the elderly are associated with multiple risk factors and that men and women might experience falls from different factors (Campbell, Borrie, & Spears, 1989).

These falls can be a burden on the health care system. A group of doctors in Washington state looked at the financial burden that falls generate. They found that fall related trauma accounted for 5.3 percent of all hospitalizations of older adults, with hospital charges totaling 54 million dollars, and resulted in discharge to nursing care more often than other hospitalizations (Alexander, Rivara, & Wolf, 1989).

Balance and Strength Training

Judge, Lindsey, Underwood, and Winsemius (1993) conducted a study to determine if a vigorous program of lower extremity strengthening, walking, and postural control exercises would improve the single-stance balance of healthy older women and lower the risk of falls and fall associated injuries. Twenty-one women were placed in the treatment group (combined training, n=12), and control group (flexibility training, n=9). The subjects ranged in age from 62 to 75 years with a mean of 68 years. The effects of the two training groups were compared with respect to static balance. The combined training group exercised three times per week on knee extension and sitting leg press machines, walked briskly for 20 minutes at 70 percent of heart rate maximum, and performed postural control exercises. The flexibility training group performed postural control exercises once per week, but did not begin that procedure until the twelveth week of training. Measurements of balance were obtained on a force platform in double and single stance, at the beginning and following six months of exercise training.

The results indicated that double stance measurements were unchanged after training. The mean displacement of the center of pressure in single stance improved 17 percent in the combined training group and did not change in the flexibility training group. The differences in improvement between the combined training and flexibility training groups were not significant.

Parsons (1992) implemented a study looking at the effects of a heavy-resistance strength training program on strength, work capacity, and balance. Eleven subjects (6 women and 5 men) whose ages averaged 79.9 years, were enrolled in the study. The exercise program consisted of five weeks of pre-training at 40 percent of a 1 RM and progressed every five weeks for 20 weeks to 80 percent of 1 RM. The exercises used were the bench press and squat. Balance tests were performed using a Chatteex Balanciometer to calculate the percent time-of-displacement away from the center of gravity. The balance tests were performed on a stationary and moving force platform with the eyes of the subject open and closed.

The percent increase in strength for women was 141 percent and 82 percent for the squat and bench press, respectively, compared to a 46 percent and 34 percent on these measures increase for men. There was no difference between pre and post maximal oxygen uptake, but work capacity increased. There were no differences in the pre and post training displacement scores on the stationary platform, whereas, on the moving platform there was a 31 percent decrease in displacement with eyes open and a 26 percent decrease with the eyes closed.

From this study is was concluded that women had greater strength gains than men and that the increase in strength in both men and women contributed to the improvement in work capacity and balance.

Topp, Mikesky, Wigglesworth, and Edwards (1992) conducted a similar study, employing a partial "home exercise plan", to determine if balance among adults age 65 and older was affected by 12 weeks of dynamic resistive strengthening exercises for the upper and lower body. Fifty-five subjects were divided into an exercise (n=25) and control (n=30) groups. During the final week of training the exercise group was able to complete three sets of each lower body exercise and two sets of each upper body exercise utilizing extensible rubber tubing sufficient to result in fatigue following 10-12 repetitions.

One weekly exercise session was supervised by a trained exercise instructor who verified technique, repetitions, and sets. The remaining weekly prescribed sessions were performed by the subject at home, and documented by the subject in a daily exercise log. To evaluate balance, a modified Rhomberg battery was administered both pre and post training. This battery included timing a one-legged stand with eyes opened and closed, and recording the number of errors made while walking backwards, toe-to-heel on a line.

Results indicated that there was a significant improvement in both exercise and control groups in the balance test with the eyes open. The balance time with the eyes closed did not change in the exercise group and deteriorated in the control group. The ability to walk backward toe-to-heel, improved in the exercise group and remained unchanged in the control group.

The investigators concluded that older adults who engage in dynamic strength training will maintain or significantly improve measures of balance. Improvements in balance among older adults have been demonstrated to reduce falls and increase the age at which the elderly can function independently.

Summary

Most of the early studies involving strength training in the elderly focused on relatively few muscle groups and employed only men as subjects. Women and more balanced exercise protocols have been included in recent research on this aging population.

The review of literature has revealed that strength training can improve upper and lower body strength in older adults up to 96 years of age. The number of subjects in many of the investigations have been less than 20, but statistical significant improvements have been shown in spite of these small numbers.

Recently, several investigations have studied the role of strength training in attempting to improve balance in older adults. According to Topp et al. (1992) older adults who engage in dynamic strength training will maintain or significantly improve measures of balance. These improvements in balance can lead to improved self-concept, improved functional capacity in every day activities, increased muscular strength which can decrease the risk of falling and the chance of injury.

CHAPTER III

METHODOLOGY

The following chapter describes the subjects, design of the study, the pre and post-training tests, and the training program.

Subjects

Twenty-seven adult subjects (12 males and 15 females) between the ages of 60 and 87 years participated in this study. Forty-four percent of the subjects were male (n = 12), and 56 percent of the subjects were female (n = 15). One-hundred percent of the population was Caucasian. The median age was 68.9 years. Subjects were recruited from the Adult Fitness Program at Eastern Illinois University. Their length of membership in the program varied from one month to 28 years.

Prior to the study, an informational letter was handed to all morning track participants in the Adult Fitness Program over 60 years of age (Appendix A). Letters were given to 75 individuals. A total of 26 individuals volunteered to participate, of which four were excluded for various physical problems or other reasons (bad back, bad knees, and out of town during the training period). Twenty-two individuals were placed in the training group. Four members of the Adult Fitness Program noon walkers and joggers were assigned to the control group along with one member from the morning walking group. Noon walkers and joggers were used as controls since they had similar demographic information as the experimental group. Demographic information concerning both groups is described in Appendix B.

Some of the subjects admitted to occasionally having pains in the back, legs, and knees but since they were already involved in the Adult Fitness Program they were allowed to take part in the study.

All participation was on a volunteer basis with the understanding that anyone could freely withdraw from the study at any time (see Informal Consent, Appendix C).

Design of the Study

All subjects in the experimental group (EG) and the control group (CG) were administered the same battery of physical testing: static and dynamic balance, along with muscular strength and endurance. Prior to the training program, initial testing (T1) was performed in the Human Performance Lab, Athletic Training Room, and the Rifle Range. After the ten week training program, final tests (T2) were administered.

The training period was from February 21, 1994 until April 29, 1994. Subjects in the experimental group performed their exercise routines before or after their walking/jogging program every Monday - Wednesday - Friday morning. Each exercise routine was performed in the Rifle Range, approximately 20 yards from the fieldhouse track. Each exercise session was recorded on a log card with the number of sets, repetitions, and time marked for the appropriate day (see Appendix D). The investigator or an assistant was present for all training sessions to observe that the exercises were being done correctly and to adjust work progressions when needed.

Subjects in the CG continued with the normal walking/jogging routines but did not participate in the activities assigned to the EG.

Pre - Training Testing Procedures

Subjects came to the Human Performance Laboratory for their testing. Groups of four individuals came in for testing every half hour. Each group performed the same order of tests: Static Balance, Dynamic Balance, Foot Extension Strength, Lower Leg Isometric Extension Strength, Lower Leg Isotonic Extension Strength, Foot Extension Endurance Time, and Lower Leg Extension Endurance Time. The following section describes the test battery.

Static Balance - Stabilometer

A Lafayette Stabilometer was used to measure how long a person remained balanced during a 30 second time period. The subject stood on the balance platform with feet shoulder width apart. Subjects were permitted to hold on to a book shelf directly in front of them to get balanced initially. After balance was achieved the investigator told the subject to let go of the book shelf and a start switch activated an electronic master time clock and an electronic counter clock. The master clock was preset for 30 seconds and at the end of the 30 seconds it would stop. The counter clock started at zero and counted up to 30 seconds. When the subject fell out of balance more than 15 degrees to either side of a line parallel with the base of support, the counter clock would stop and not start again until the platform was in balance.

The subject attempted to stay in balance for the full 30 seconds. When the test was completed the investigator helped the subject off the platform and repositioned the subject for the next trial. Three trials were given for each subject with the best trial (longest time "in balance") recorded.

Static Balance - Stork Stands (Eyes Open and Closed)

A one-legged stork stand (with eyes open and closed) was also used to measure static balance. The subject was told to stand on one leg and balance for as long as possible, up to 30 seconds, without touching the opposite foot to the floor. Subjects were permitted to position their arms out to the side and to hop if necessary, on the balancing foot. When the subject was ready the investigator started a hand-held watch and timed how long s/he could balance on one foot. This procedure was done for the right foot and the left foot. Separate trials were given with the eyes closed. The test was stopped as soon as the opposite foot touched the floor or the subject remained balanced for the full 30 seconds. Four scores were recorded for each subject: right and left foot eyes open and right and left foot eyes closed.

Dyanamic Balance - A Modified Bass Test

The Bass Dynamic Balance Test, as it appeared in the early literature was not practical for this sample of subjects (McCloy & Young, 1954). Modifications resulted in the following procedure.

A grouping of 10 circles, eight inches in diameter, was drawn out on the tile floor of the Exercise Science Classroom. A water soluble red marker was used for easy visibility. The circles were positioned 18 inches apart and at the angles prescribed by the original Bass test McCloy, et al. (1954). The angles between circles were measured with a protractor with the center of each circle as the base point for each angle.

The subject was given a demonstration by the investigator and a practice "walk through" was allowed for familiarization with the course. When the subject was ready s/he started with the ball of their left foot in the first circle and then attempted to hold steady for three seconds. The subject then proceeded to step to each circle alternating feet each time. At the conclusion of the first trial, the subject was given one-to-two minutes rest before starting the next trial. Generally, two trials were given for each subject unless one trial was very unsatisfactory in which case another trial was given.

To assist in objectively scoring the test, a video camera was placed directly behind the subject to get a better view of the heel and the floor. Portable lights were positioned on chairs so as to shine more light on the floor and to remove shadows directly under the foot. Replaying the video tape at a reduced speed, allowed the investigator to more carefully study the monitor and score the trial. A description of the scoring system used for the Modified Bass test is presented in Appendix E.

<u>Foot Extension Strength - Cable Tensiometer</u>

A Pacific Cable Tensiometer was used to measure the foot extension strength of the gastrocnemius and soleus muscles of the lower leg. The subject sat on a table with the lower back and upper buttocks flat against a wall directly behind them. Both legs were fully extended on top of the table away from the wall. An eye bolt secured into the wall was used to attach a cable which was extended parallel along the subject's leg. A metal foot device, similar to a bicycle pedal shoe harness, was attached on the end of the cable. Turn-buckles and s-hooks were used to lengthen or shorten the overall length of the cable system depending on the leg length of the subject.

After the subject's back was flat against the wall, the legs forming a 90 degree angle with the spine and the knee joints completely flat against the table, the metal foot device was positioned on the foot. The investigator placed the tensiometer on the cable running parallel to the subject's leg. The investigator then told the subject with maximum effort to extend his/her foot or imagine depressing an acceleration pedal on an automobile. The investigator noted the highest force applied and recorded the score. Three trials were given for each foot with investigator recording the greatest force applied for the right and left feet.

The cable tensiometers were calibrated after each subject's trials. A calibration bar attached to the carrying case was used. Each tensiometer (200 and 450 pounds capacity) had an individual calibration bar. To calibrate, the investigator placed the bar inside the cable holders then released the handle. If the tension recorded was inconsistent with the bar tension, the dial was manually reset to either 200 or 450 pounds, respectively, thus calibrating the devices.

Lower Leg Isometric Extension Strength

Quadricep strength was measured using the Universal Machine-Leg Extension Device. Two separate tests were performed on this apparatus. First, a maximum one-legged isometric contraction was measured using the cable tensiometer and secondly a one-repetition maximal isotonic contraction was performed using both legs.

The isometric one-legged contraction was the first test performed on all the subjects. The weight stack was lifted off the base and a wooden dowel was placed under the stack to keep it upright while the subject raised his/her leg upward until a "behind the knee" 120 degree angle was achieved. When the angle was correct the investigator placed the cable tensiometer on the cable running from the weight stack to the foot bar. The subject was then told to attempt to extend the lower leg at this 120 degree angle with a maximal effort until s/he was told to stop.

This same procedure was followed for the opposite leg. Three alternating right and left leg trials were given with the best score recorded for each leg. For subjects shorter in height, another bar was clamped across the original bar to insure a consistent lower leg lever arm length. Foam cushions were fastened around the bar to provide more comfort. The same procedure was followed for the modified isometric test.

Lower Leg Isotonic Extension Strength

The subject then performed a maximal isotonic contraction with both legs. The subject was instructed to sit upright with their back perpendicular to the machine's cushioned seat/table. The investigator sat directly behind the subject to give lower back support and to more clearly isolate the lower leg extension muscles during the test. The subject was also informed to place his/her hands on the sides of the seat/table for better stability.

Preliminary repetitions were performed to warm-up the muscles and familiarize the subject with the test. Weight was progressively added until maximal effort was achieved. The maximal effort was determined when the subject could no longer fully extend the lower leg with a fixed amount of weight.

Weight progressions were determined by the investigator who evaluated the previous isometric test to determine the increase in weight increments.

Foot Extension Endurance Time

Using the subject's own body mass and 20 pounds of additional weight as the resistance, participants were asked to perform a "heel raise" exercise to determine the endurance of the gastrocnemius and soleus muscles.

The subject was given a 10 pound dumbbell to hold in each hand and stand approximately two feet away from a wall. The investigator instructed the subject to raise up on the balls of the feet, while he placed a one inch wooden block under the heels.

To begin the test, the investigator started a hand-held stop watch and simultaneously instructed the subject to raise up on the balls of the feet. The subject was encouraged to hold this position for as long as possible. The test was stopped when the heels touched the block or 90 seconds had elapsed. During the trial, the subject's heels were allowed to move up and down as long as they did not come in contact with the wooden block. One trial was given with the time being rounded to the nearest second.

Lower Leg Extension Endurance Time

The wall-squat exercise, performed at a behind-the-knee angle of 120 degrees was used to determine the endurance of the quadricep muscle group.

The subject stood with his/her back against the wall and his/her feet one to one -and- a half feet away from a wall. With the whole back and buttocks flat against the wall while keeping the feet firmly in position, the subject was instructed to "slide down" the wall, until a knee angle of 120 degrees was achieved. The investigator held a goniometer against the outer thigh and lower leg so as to accurately measure the angle. When the angle was achieved the time clock was started. A stationary clock was placed in front of the subject and a short wooden bench was placed below the buttocks of the subject to protect the participant from knee injury in the event s/he could not hold the proper angle.

The test was stopped when two minutes elapsed or when the subject could no longer hold the fixed position. One trial was given per subject with the time being rounded to the nearest second for a score.

It should be noted that for this test, as with the Foot Extension Endurance Time Test (Heel Raise), a predetermined end point was chosen so as to protect the musculature from becoming excessively stiff and sore. These two tests then were not so much chosen for their discrimination ability, but instead they acted as general indicators for starting points.

Training Procedures

The training procedure was similar for all subjects throughout the study. The only individual variations between subjects were the progressions in frequency, intensity, and duration as prescribed by the investigators. Note the training chart presented in Appendix F.

These progressions, modifications to training, were determined by asking the subject how s/he felt and if they could do more. The investigator was very aggressive in overloading the subjects due in part to the relatively short ten week training period. If a subject experienced pain or fatigue a decrease effort was suggested or more rest time was allocated between exercises and sets.

If subjects knew they would miss an exercise session they were instructed to alert the investigator ahead of time. Make-up sessions were scheduled throughout the duration of the study. Weekends, Tuesdays, and Thursdays (off days) were used as make-up days when they were needed.

Periods of time also occurred when particular subjects were absent for extended periods of time (up to two weeks). This situation arose on four separate occasions. When this happened the investigator wrote down the training session and gave it to the individual so it could be performed at home. A cardboard triangle at 120 degrees (matching the training angle) was also given to each subject for an accurate measure of the wall squat position. The subjects were required to keep a log of the days that they exercised and turn it in to the investigator when they returned. The "home sessions" were transferred onto the log card.

Make-up sessions performed with the investigator present counted as one make-up session. Only one make-up session could be made up per make-up session day.

The investigator also instructed each subject not to perform the exercises at home or on the "off" days during the study. The only outside implementation of this particular training routine was the prewritten training routines given to subjects that were going to miss sessions.

The procedure for each work-out was the same. Subjects reported to the training room (Rifle Range) and performed their routine. The investigator recorded what was actually accomplished that day on each subject's log card. Also, at the conclusion of each work-out, the investigator would ask the subject how the session went. From visual observations and verbal communication, the investigator made progressive adjustments in the overload for the subjects.

Training Exercises

A brief description of the training exercises appears below. Generally, subjects performed the exercises in the following order so as to provide some periods of alternating rest to the musculature. The total time for the exercise routine varied between 10 and 20 minutes depending on the speed and enthusiasm of the subject. As the subject progressed, the routine took slightly more time.

Wall Squats:

The procedure for the exercise was the same as the test except for the duration. All subjects started at a duration of 20 seconds with a gradual increase in time. An overload was also added by making the knee joint angle 90 degrees instead of 120 degrees. The subjects performed three to four sets for various lengths of time with between 15-60 seconds rest between sets.

Stork Stand:

The procedure for the stork stand was the same as for the static balance tests except for the duration. The eyes were open for all the sets. All subjects started at a duration of ten seconds on each foot, performing four alternating left and right sets with each foot. The duration varied between 10 and 45 seconds depending on the skill of the subject. Subjects used their own wrist watch or a portable clock to time themselves. Arms were allowed to be raised to the sides for added stability.

Chair Squats:

The chair squats were performed by sitting on a chair then standing upright and sitting back down again. The feet were kept shoulder width apart and the arms kept at the sides throughout the full range of motion. Subjects were instructed not to slouch forward but to keep the back as straight as possible during the movement. All squats were performed on folding chairs in the Rifle Range, each of which were 17 inches of the ground (at seat level). Sets and repetitions varied depending on the strength and endurance of each individual. Everyone started with three sets and five repetitions, with some working up to five sets and 20 reps, respectively.

Heel-to-Toe Walk:

The heel-to-toe walk was performed by walking in a straight line, one foot directly in front of another (heel-to-toe). The subjects followed a one inch wide straight line that was painted on the floor. The routine included walking approximately 10 feet in a straight line for four consecutive trips. As balance improved, subjects were asked to perform the same type of routine while walking on a one inch by three inch board that was 14 feet in length. The board was positioned on the floor and subjects were permitted to look down at their feet and raise their arms to the sides for better stability.

Heel Raises:

The heel raise was performed by standing directly behind a folding chair with the feet shoulder width apart. Subjects would raise up on the balls of the feet, hold that position for one second, then return the heels to the floor. Subjects capable of additional overload, placed the balls of their feet on a half inch board on the floor. Then they performed the exercise in the same manner as before. Repetitions and sets varied depending on the progress of the individual. Everyone started with three sets of five repetitions, with some working up to five sets and 25 reps, respectively.

Post-Training Testing Procedures

Post-training testing procedures were similar to the pre-training procedures. Subjects came to the Human Performance Laboratory for their testing. All subject came in groups of four and performed the tests in the same order as the pre-test. Generally, within a one week time period all subjects were retested following the end of the training period.

CHAPTER IV

RESULTS

Sample

Twenty-seven members of the EIU Adult Fitness Program took part in the ten week leg strength and static/dynamic balance training program. The 22 subjects in the Experimental Group (EG) achieved an adherence average of 97 percent of the total possible training sessions. Five individuals were included in the Control Group (CG).

Three different sets of t ratio's were calculated (Stat View, 1988). First a pre-test (T1) and post-test training (T2) comparison was made for subjects in the EG to see if any of the measured abilities had changed during the ten weeks. Second, a similar pre-test and post-test comparison was made for members of the CG. Finally, t ratio's were calculated for the average differences of the EG compared to the average differences of the CG over the ten week period.

Experimental Group: Pre-Post Training Test Changes

Table I reveals in all 11 of the strength/balance parameters, subjects in the EG made improvements over the scores they posted in the pre-training trials. In all six of the balance items and in all five of the strength items, there were statistically significant improvements ($p < 0.05$). It is interesting to note that the subjects more than doubled their ability to balance on one foot with their eyes closed while they also made very significant improvements in their ability to balance on one foot with their eyes open.

TABLE I

Experimental Group Means: Pre (T1) and Post (T2) Training Comparisons

Test	T1	T2	t ratio	Level of Significance
Static Balance				
Stabilometer	23.434 sec.	26.499 sec.	-3.983	.0007*
Stork Stand Open - Right	16.900 sec.	24.800 sec.	-3.880	.0009*
Stork Stand Open - Left	16.500 sec.	25.800 sec.	-4.536	.0002*
Stork Stand Closed - Right	5.800 sec.	13.400 sec.	-5.076	.0001*
Stork Stand Closed - Left	5.800 sec.	13.200 sec.	-4.355	.0003*
Dynamic Balance				
Bass Test	33.000 pts.	37.300 pts.	-3.672	.0014*
Foot Extension Strength				
Right	115.100 lbs.	145.500 lbs.	-6.535	.0001*
Left	102.300 lbs.	148.500 lbs.	-8.458	.0001*
Isometric Extension Strength				
Right	60.200 lbs.	76.900 lbs.	-7.464	.0001*
Left	57.000 lbs.	76.900 lbs.	-4.734	.0001*
Isotonic Extension Strength - Maximal				
	49.100 lbs.	92.500 lbs.	-9.141	.0001*

* Denotes statistical significance beyond the .05 level of confidence

Discussion

Foot Extension Strength and Lower Leg Isometric Extension Strength, both right and left feet and legs, made dramatic improvements in the strength parameters measured. The largest improvement was in Isotonic Leg Strength which increased 88 percent over the ten week training period. Other factors along with increased strength and balance could also contribute to the improvements that were made. Sight, hearing, touch, and improved neuromuscular control could also contribute to increases in strength and balance.

Control Group: Ten Week Changes

Table II reveals that in six of the parameters T2 score were lower than T1 scores, while there was a slight improvement on five of the items. None of the improvements came close to meeting the .05 level for statistical significance. It should be noted that one individual showed improvements bringing the whole group's average higher. This improvement might have been due to the fact that the subject might not have given his best effort during the pre-test.

Discussion

As was expected, the CG showed no statistical improvements in strength or balance over the ten weeks. This should be of no surprise considering the CG did not perform any of the training program exercises. Originally, there were nine individuals in the control group. Sickness and discontinuation of the exercise program were the reasons for the final number in the control group.

TABLE II

Control Group Means: Ten Week Changes

Test	T1	T2	t ratio	Level of Significance
Static Balance				
Stabilometer	20.479 sec.	20.383 sec.	1.204	.2951
Stork Stand Open - Right	14.400 sec.	13.400 sec.	.953	.3943
Stork Stand Open - Left	17.600 sec.	17.200 sec.	.535	.6213
Stork Stand Closed - Right	5.200 sec.	5.200 sec.	0.000	-----
Stork Stand Closed - Left	5.600 sec.	6.600 sec.	-1.414	.2302
Dynamic Balance				
Bass Test	29.000 pts.	30.200 pts.	-0.590	.5870
Foot Extension Strength				
Right	88.200 lbs.	88.000 lbs.	0.071	.9465
Left	91.800 lbs.	89.000 lbs.	1.071	.3446
Isometric Extension Strength				
Right	51.200 lbs.	58.400 lbs.	-1.663	.1716
Left	49.800 lbs.	58.800 lbs.	-2.189	.0938
Isotonic Extension Strength - Maximal				
	54.000 lbs.	56.000 lbs.	-1.633	.1778

EG and CG: Average Difference Comparisons

Table III reveals the average difference comparisons between groups for each of the tests. In comparing the two groups only four of the 11 measures made the .05 level of confidence: Stork Stand Eyes Open left leg, Foot Extension Strength right and left feet, and Isotonic Leg Extension Strength. Three other measures came close to reaching the .05 level of confidence: Stork Stands: Eyes Open right leg, Eyes Closed both legs.

Discussion

The author believes that if more individuals had been part of the control group that some of the testing parameters might have reached statistical significance. As mentioned earlier, the one control showed vast improvement in his post-test scores, and with the small number of controls the group means were also improved. All individuals were right side dominant. This could be a reason why there was improvement in the left leg stork stand and no improvement in the right leg stork stand. The left leg responded more to the training stimulus and perhaps the right side did not because of the dominant usage.

Anecdotal Notes

Feedback from the participants was positive throughout the duration of the study. The author was told that the exercises had helped the individuals in more ways than one. One participant explained that for years his knees would crack everytime he would stand up and after performing the exercises for a few weeks his knees would no longer crack and his legs felt much stronger. Many

TABLE III

Experimental Group and Control Group:
Average Difference Comparisons

Test	$\overline{X}EG$	$\overline{X}CG$	_t_ ratio	Level of Significance
Static Balance				
Stabilometer	3.100 sec.	-0.500 sec.	-1.810	.1450
Stork Stand Open - Right	7.900 sec.	-1.000 sec.	-2.640	.0573
Stork Stand Open - Left	9.200 sec.	-0.400 sec.	-3.150	.0346*
Stork Stand Closed - Right	7.600 sec.	0.000 sec.	-2.400	.0743
Stork Stand Closed - Left	7.400 sec.	1.000 sec.	-2.450	.0705
Dynamic Balance				
Bass Test	4.300 pts.	1.200 pts.	-1.600	.1856
Foot Extension Strength				
Right	30.300 lbs.	-0.200 lbs.	-3.540	.0241*
Left	46.200 lbs.	-2.800 lbs.	-5.060	.0072*
Isometric Extension Strength				
Right	16.700 lbs.	7.200 lbs.	-2.240	.0890
Left	20.000 lbs.	9.000 lbs.	-0.130	.9041
Isotonic Extension Strength - Maximal				
	4.300 lbs.	1.200 lbs.	-1.600	.0038*

* Denotes statistical significance beyond the .05 level of confidence

other comments like “stronger legs”, “more endurance”, “better balance”, “easier time of climbing stairs”, and others were expressed by many of the participants.

Even though some of the measures did not reach statistical significance the author believes that this study was very beneficial to the individuals involved.

CHAPTER V

SUMMARY

The purpose of this study was to determine the effects of three weekly strength and balance exercise routines on selected muscular strength and balance parameters on an older (ages 60-88 years), active population of men and women.

Twenty-two, men and women, members of the Adult Fitness Program volunteered to participate in the study which was conducted over a ten week period of time. An additional five individuals acted as exercise controls.

Prior to the training, and directly after the ten week period, selected muscular strength and balance tests were administered. These tests consisted of: Static Balance (stabilometer, stork stands with the eyes open and closed), Dynamic Balance (Modified Bass test), Foot Extension Strength (cable tensiometer), Lower Leg Isometric Strength (cable tensiometer), Isotonic Leg Extension Strength (Universal leg extension machine).

Each of the 30 training sessions consisted of three leg strength exercises (chair squats, wall squats, and heel raises), and were interspersed with two balance exercises. One-legged stork stands with the eyes open and closed and a heel-to-toe walk routine made up the balance exercises. Initial starting points were determined from Pre-Training Test results and progressions were made by either increasing the number of sets or the number of repetitions.

Dependent t-tests were used to determine if the changes between the pre and post training test data were significant. The .05 level of confidence was used to denote statistically significant differences.

There was a statistically significant improvement for all 11 muscular strength and balance measures when the pre and post training tests for the experimental group were compared. No statistically significant improvements were seen for the members of the control group on any of the test items.

When pre and post training changes for the experimental group were compared to the pre and post ten week changes for the control group, the following findings were determined to be statistically significant. The improvements made by the experimental group were superior in one balance item (Static Balance - stork stand eyes open, left foot) and three strength items (Foot Extension Strength - right and left feet, and Isotonic Leg Extension Strength).

Conclusions

The findings of this investigation revealed that after performing a ten week, three sessions per week training program as described in the study, that some muscle strength and balance parameters can be significantly improved in an older (ages 60-88 years), active population of men and women.

These results agree with much of the current literature in supporting the thesis that older adults can improve their muscle strength and balance by strength and balance training even if the participants are already active walkers and joggers.

This study also demonstrates that a simple 10-12 minute routine, that could conceivably be performed at home, can have a beneficial effect in older, active men and women. These beneficial effects, in combination with other factors might help reduce the risk of falling.

Recommendations

As a result of the findings, the following recommendations are made.

Since strength and balance are contributors to one's ability to avoid falling, it would be interesting to see if those adults over age 60 who faithfully follow a specific training routine, over a period of years, can reduce the falls and serious health problems that often result as the aging process continues.

A written hand-out or pamphlet should be developed and made available to adults outlining the potential benefits of a regular strength and balance exercise routine.

A written (Likert-type scale) questionnaire be handed out to individuals before and after the exercise program to determine if there are any perceptions or general feelings that have changed. This could be used to determine if people's ideas, thoughts, or fears about about falling change if they participate in an exercise and balance training program.

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APPENDIX A

PRE-STUDY INFORMATIONAL LETTER

Dear Adult Fitness Participants,

Hi everyone, this is Brad Campbell, a graduate student of Dr. Woodall's. I hope 1994 is going well for everyone. The reason I am writing this note to you all is that I am going to be starting a research project and I would like to have volunteers from the Adult Fitness Program.

The project itself is going to include an exercise routine that will emphasize muscular strength and balance. As we get older the body becomes more susceptible to falls and injury. What I want to do is to implement an exercise and balance routine that will improve muscle strength and balance in the lower body.

The project will last approximately 10 weeks with three exercise sessions per week. I will be leading the sessions which will take place either in the fieldhouse or an adjoining room. The sessions will take place on Monday-Wednesday-Friday after everyone's normal walking session is over. Each session is not mandatory but the 30 total sessions is. If a session cannot be attended then make-up times can be arranged on a Tuesday-Thursday or weekend. But it is important to complete the 30 sessions.

The tentative starting date would be Monday, Feb. 21st and the ending date would be Friday, April, 29th. This is subject to change.

Along with the regular exercise sessions there would also be two dates set aside strictly for measurement of each individual's strength and balance by a few short, simple tests. This would occur before and after the starting dates indicated above. The first pre-testing date is scheduled for either Friday 18th or Saturday 19th depending on the number of persons interested.

This will be a very exciting project and I hope you are interested in this also. I will be getting in touch with you to answer any questions and to verify how many would be interested in participating in the project.

Thank you for your time.

Sincerely,

Brad Campbell

APPENDIX B

DEMOGRAPHIC DATA OF SUBJECTS

Subject	Group	Age (years)	Sex	Height (inches)	Weight (pounds)
1	Exp	88	M	66.5	118
2	Exp	75	F	63.0	152
3	Exp	77	F	55.5	140
4	Exp	82	M	66.0	151
5	Exp	60	M	68.0	155
6	Exp	74	M	67.0	176
7	Exp	71	F	61.0	114
8	Exp	65	M	72.5	266
9	Exp	63	F	61.0	126
10	Exp	76	F	63.0	127
11	Exp	70	F	62.0	159
12	Exp	63	F	61.5	116
13	Exp	62	M	69.0	215
14	Exp	74	F	63.0	131
15	Exp	72	M	72.0	222
16	Exp	64	F	63.0	166
17	Exp	63	F	65.0	196
18	Exp	61	F	63.5	174
19	Exp	64	F	71.0	228
20	Exp	62	M	73.5	171
21	Exp	71	M	70.0	154
22	Exp	63	M	63.0	135
23	Con	70	M	68.5	170
24	Con	71	F	63.0	137
25	Con	70	F	60.5	201
26	Con	73	M	68.0	189
27	Con	70	F	60.0	110

APPENDIX C

CONSENT FOR PARTICIPATION IN A RESEARCH PROJECT

I, ____________________, state that I wish to participate in the research project conducted by Brad Campbell.

The purpose of this research project is to investigate physiological effects of strength training done three times per week for 10 consecutive weeks and how it affects selected muscular strength and balance tests. This research project is being conducted with volunteers from the EIU Adult Fitness Program.

My participation involves approximately 1-2 hours of time in the Human Performance Laboratory at EIU. These hours are divided into two separate testing sessions, separated by approximately 10 weeks. Both sessions will consist of a series of lab tests which will include: a muscular strength test and balance tests.

While participating in this research project, I agree to participate in the Strength and Balance sessions every Monday, Wednesday and Friday before, during or after my normal Adult Fitness exercise session. The sessions will take 5-10 minutes. Make-up sessions can be done with approval from Brad Campbell.

Potential benefits of this study include, increased muscular strength, improved balance and coordination. The personal risks are minimal, and are those associated with muscle soreness and fatigue. I may discontinue participation at any time during this research project. If I have any questions, Brad Campbell has offered to answer them. I consent to the anonymous use of my information for use in this research project. Any photographs or movies taken during this study may be used in the manuscript and/or during lectures presenting this study.

I have read the above statement and do understand all risks and benefits associated with this study. I freely and voluntarily consent to my participation in this research project.

____________________ ____________________________

Date Signature of Volunteer

____________________ ____________________________

Date Signature of Witness

APPENDIX D

LOG CARD

WORKOUT RECORD CARD FOR ______________________________

WK	1	2	3	4	5	6	7	8	9	10
	MWF	MWF	MWF	MWF	MWF	MWF	MWF	MWF	MWF	MWF
EX										
WS										
SS										
CS										
HT										
HR										

APPENDIX E

MODIFIED BASS TEST SCORING SYSTEM

1. Grade each circle individually. Each circle has three criteria which are scored separately (Step, Maintanence,and Balance). Ten points are possible for each circle and with ten circles a maximum score of 100 is possible. The criteria are described as follows:

A. Step

2 pts = on toes completely
1 pt = on toes (some instability)
0 pts = on heel

B. Maintenance

2 pts = heel does not touch the floor
1 pt = heel occasionaly touches the floor
0 pts = heel consistently on the floor

C. Balance

6 pts = stability, opposite foot does not touch the floor, hands do not touch the floor, foot not outside the circle
5 pts = good stability, opposite foot does not touch the floor, hands do not touch the floor, foot occasionally out of circle
4 pts = some stability, opposite foot touching the floor, hands do not touch the floor, foot outside of circle
3 pts = occasional stability, frequent touching of the opposite foot to the floor, hands not touching the floor, foot outside the circle
2 pts = poor stability, opposite foot touching the floor very frequently, hands not touching the floor, foot outside the circle
1 pt = very poor stability, opposite foot on the floor, hands touching the floor, foot outside the circle
0 pts = no stability, opposite foot on the floor, hands touching the floor, foot outside the circle

APPENDIX F

TRAINING CHART

	WALL SQUATS			STORK STAND	CHAIR SQUATS	HEEL-TOE			HEEL RAISE
WORKOUT #	DE	SETS	SEC	M - W - F	SETS/REPS	WID	R	SEC	SETS/REPS
1-3	120	3	20	4 SETS 10 SEC	3 X 5	FL	4	2	FL 3 X 5
4-6	120	3	25	4 SETS 12 SEC	4 X 5	FL	4	2	FL 3 X 5
7-9	120	4	30	4 SETS 15 SEC	3 X 7	FL	4	2	FL 3 X 7
10-12	120	4	35	4 SETS 18 SEC	4 X 7	BD	4	2	FL 4 X 8
13-15	90	3	20	4 SETS 20 SEC	4 X 8	BD	4	2	BL 4 X 8
16-18	90	3	25	4 SETS 25 SEC	4 X 10	BD	4	2	BL 4 X 10
19-21	90	3	30	4 SETS 30 SEC	4 X 12	BD	4	2	BL 4 X 12
22-24	90	3	35	4 SETS 35 SEC	5 X 10	BD	4	2	BL 5 X 10
25-26	90	3	40	4 SETS 40 SEC	5 X 12	BD	4	2	BL 5 X 12
27-30	90	4	30	4 SETS 45 SEC	5 X 15	BD	4	2	BL 5 X 15
31-33	90	4	35	4 SETS 45 SEC	5 X 20	BD	4	2	BL 5 X 20
34-36	90	4	40	4 SETS 45 SEC	5 X 25	BD	4	2	BL 5 X 25
37-39	90	4	45	4 SETS 45 SEC	6 X 20	BD	4	2	BL 6 X 20
40-42	90	4	45	4 SETS 45 SEC	6 X 25	BD	4	2	BL 6 X 25

WALL SQUATS:
- DEGREES
- SETS
- SECONDS PER SET

STORK STAND:
- SETS PER FOOT
- SECONDS PER FOOT

CHAIR SQUATS:
- SETS AND REPS

HEEL - TOE WALK:
- WALKING ON FLOOR OR BOARD
- SETS
- SECONDS BALANCED PER STEP

HEEL RAISES:
- SETS AND REPS