Post-menopausal Women and Exercise for Prevention of Osteoporosis

Lauve Metcalfe, Tim Lohman, Scott Going, Linda Houtkooper, Dawna Ferriera, Hilary Flint-Wagner, Terri Guido, Jane Martin, Jill Wright, Ellen Cussler

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direct correspondence to:
Lauve Metcalfe
University of Arizona
113 Gittings
Tucson, Arizona 85721

phone: 520.621-6988
fax: 520.621-8170
e-mail: Lauve@u.arizona.edu

Post-menopausal Women and Exercise for Prevention of Osteoporosis: The Bone, Estrogen, Strength Training (BEST) Study

Lauve Metcalfe, Tim Lohman, Scott Going, Linda Houtkooper, Dawna Ferriera, Hilary Flint-Wagner, Terri Guido, Jane Martin, Jill Wright, Ellen Cussler

Learning Objective: *To learn if it is possible to develop a community-based program for postmenopausal women that could improve bone health and prevent osteoporosis.*

The many demands on women's time ranging from family, work, and community involvement makes exercising regularly a challenging task. Would participation in a rigorous exercise program be even more difficult for post-menopausal women who have been sedentary? Is it possible to develop a community-based exercise program for post-menopausal women that could improve bone health and prevent osteoporosis? The Bone, Estrogen, Strength Training (BEST) Study set out to answer these questions. This study was sponsored by the National Institute for Arthritis and Musculoskeletal Diseases, of the National Institutes of Health and Mission Pharmacal. It was conducted by the University of Arizona Departments of Physiology and Nutritional Sciences. The background, development concepts, and keys to success behind the BEST study are presented in this article.

Background

Osteoporosis is a significant health problem in the United States. Over 25 million people in the U.S. are affected by osteoporosis, most of whom -80%- are women. Women who are not receiving hormone replacement therapy (HRT), not consuming adequate amounts of calcium and are inactive can lose 20-30% of their bone mass between 40-70 years of age. As a result, women have a 40% fracture risk over their lifetime, with over 1.5 million fractures per year attributed to osteoporosis. Hip fractures, one of the primary fracture sites, have the highest prevalence rate at 250,000-300,000 fractures per year. Annual costs are estimated at $13.8 billion for medical care.

The results of previous exercise programs for postmenopausal women that aimed to increase bone mineral density (BMD) demonstrate that resistance training is positively associated with an increase in BMD in older adults. The effect of resistive exercise is site-specific, with bigger responses at the sites where working muscles attach to bones. Although aerobic exercise and weight-bearing activity are important in maintaining overall health, and may contribute to maintenance of healthy bone, resistance exercise seems to have a more significant impact on bone density.

Previous research focusing on strength-training programs with postmenopausal women not on HRT found that bone mass can be significantly increased by a strength-training regimen that uses high-load, low repetitions, but not by an endurance regimen that uses low-load, high repetitions (1,2).

Studies examining the effect of HRT and resistance weight training suggest that the efficacy of HRT is enhanced by combining it with weight-bearing exercise. Not only do estrogen and exercise have additive effects by increasing bone mineral density, but the increase in muscular strength and functional capacity that occurs in response to exercise also reduces the incidence of osteoporotic fractures by reducing the risk of falling (3,4).

The BEST Study

The BEST study was designed to examine the effects of exercise on BMD in two populations (HRT and no HRT) of sedentary postmenopausal women. A total of 266 women completed the one-year program, making it the largest study to date investigating the effects of exercise on BMD involving postmenopausal women. The investigators are continuing to track the exercisers and control subjects to observe the long-term effect of exercise in this population.

Primary recruitment strategies used television, radio, and newspaper advertisements and flyers distributed in the community to encourage eligible women to attend informational meetings. Participants were postmenopausal, sedentary, non-smokers, with no history of bone fractures or osteoporosis. They were between 40 and 66 years of age, with an average age of 55.6 years. Their body mass index ranged from 17.9 and 35.5, and their percent fat ranged from 13.5% to 54.3%. Women using HRT (between one and five years) and women not using HRT (no HRT) participated.

Participants within each of these two groups (HRT and no HRT) were randomly assigned to an exercise group (n=142) or control group (n=124). Six cohorts of 20 to 30 women started the exercise program at six-month intervals. The control participants in each cohort continued their usual sedentary activity. All participants were provided with calcium supplements containing 800 mg of elemental calcium (Citracal®, Mission Pharmacal) per day to ensure adequate calcium intake for this population.

Assessment

Members of both the exercise and control groups completed testing at regular intervals (baseline, 6 months, 12 months) to assess the effects of the exercise

intervention on outcome variables including BMD of the hip and spine and muscle strength.

Special Considerations for Post-menopausal Women.

Past research suggests a varied exercise program including strength training, aerobic-weight bearing activity, and balance and stretching enhances mobility and functional capacity, thereby contributing to falls and fracture prevention. The primary considerations underlying the development of the BEST exercise program were:

1) to exercise at an intensity sufficient to elicit an increase in BMD in the hip and lumbar spine,
2) to select exercises specifically designed for function and mobility (leg strength for activities of daily living, i.e. squats, leg press),
3) to counter the changes in the curvature of the spine and posture of the body that occur with aging (i.e. lordosis),
4) to develop the small-muscle groups of the back that are used for stability, spinal support, and posture, and,
5) to exclude exercises that are counterproductive to maintaining a healthy posture and that put participants at risk for fracture.

Exercises were selected that would load the bone and strengthen the small- and large-muscle groups that support the spine and hip, key areas associated with osteoporotic fractures. To address the concerns with posture, exercises were chosen to realign the spine and pelvic girdle by exercising the rhomboids, lower trapezius, latissimus dorsi, erector spinae and lower abdominals.

Exercises, such as the bench press, that may promote shortening of the chest musculature and promote forward head and shoulder posture were excluded from the program. Emphasis was placed on selecting exercises to strengthen the back musculature for better posture and alignment. Another modification in exercise technique was using a supinated grip on the latissimus dorsi (lat) pulldown machine and pulling the bar down in front of the body rather than behind. This modification maintains the head in a neutral position, rather than encouraging a forward head lean. The supinated grip also provided an additional load to the wrist.

The alignment of the spine of each participant was assessed by a physical therapist to determine the position of the lumbar spine and sacral angle. Two unique positions of the spine were assessed: lordosis posture, and flat lumbar spine. Participants with spinal lordosis were not given exercises that would accentuate this

curvature, while participants with a flat lumbar spine were not given pelvic tilt exercises.

The Exercise Program

A team of exercise physiologists, a physical therapist, strength-training specialists, and health promotion programmers developed the exercise program. The program emphasized progressive resistance training to achieve the high loads thought to promote increases in BMD. Each week, subjects participated in supervised exercise sessions on three non-consecutive days for 60-75 minutes per session for one year at community fitness facilities. Sessions were held in the early morning, midday, and evenings on Monday, Wednesday, and Friday. Makeup sessions were offered on Saturday mornings. At each session, the participants completed exercise logs used to monitor attendance at the exercise sessions, document exercises, activity level, loads, number of sets, and repetitions completed at each exercise session, and to determine the level of adherence to the exercise program components. The exercisers also used the logs as a motivational tool for self-monitoring.

A BEST trainer supervised all exercise sessions. Trainers had a degree (B.S. or M.S.) in exercise science or a related field and certification by a nationally recognized fitness and strength-training organization. They were further trained in the unique features of the BEST program by a physical therapist. The average ratio of trainers to participants in the facilities was 1:5.

Program Components

The exercise program included six components shown in Table 1.

Table 1. Components of Each Exercise Session

1. Warm up (5-10 minutes)
2. Progressive weight bearing (25 minutes)
3. Resistance exercises with large muscle groups (20 minutes)
4. Resistance exercises with small muscle groups (10 minutes)
5. Abdominal strengthening (5 minutes)
6. Stretching and balance (5 minutes)

Warmup

Participants walked for 5 to 10 minutes before beginning other components.

Progressive Weight Bearing

This involved two types of activities: progressive weight-bearing movement and stepping/stair climbing (totaling 25 minutes).

Progressive weight bearing movement. The participants either walked while wearing a vest that contained added weights, beginning with 10 pounds and increasing up to 25 pounds, or completed a locomotor circuit that included skipping, jogging, hopping and jumping. Weight vests were not worn during the circuit. These exercises were performed at a minimal heart rate range of 50% and 70% of maximal heart rate (MHR) and a maximum of 80% of MHR.

Stepping/stair climbing. Participants began with four sets of 30 steps (120 steps) at a pace of two seconds per step using either a Reebok Step, or walking up and down stairs in the fitness facilities. The average step height was 8 inches. The stepping progressed to ten sets of 30 steps (300 steps). To provide an added load, vests with 10 pounds of added weight were worn, and weight was gradually increased up to 25 pounds. The weight vests were worn on days when moderate (70% of one repetition maximum [1-RM]) resistance exercise was performed.

Resistance exercises with large-muscle groups

Eight core resistance exercises were performed using machines and free weights. Exercises for the major muscle groups of the arms, legs, upper and lower trunk, emphasizing muscle attachments at the major fracture sites (spine and hip), were selected.

The exercises included back extension, latissimus dorsi pull-down using a supinated grip, leg press, rotary torso, seated one-arm dumbbell military press, seated row, weighted marching using ankle weights, and squat using a hack squat machine or Smith squat depending on the facility. Two sets of six- to eight-repetition maximum with 45 seconds to one minute of rest between sets were performed for each exercise.

After one month of technique training all exercises were performed at 70% to 80% of 1-RM. The 1-RM, or personal best (PB) was the maximal load that could be lifted once using the correct lifting technique. Moderate loads (70% to 75% 1-RM) were lifted twice per week, and heavy loads (80% 1-RM) once per week.

Resistance exercises with small-muscle groups

Exercises were performed seated or in a prone position on a physiotherapy ball. The elastic band exercises included adduction/retraction of scapula, scapular depression and extension of thoracic spine, and external rotation of humerus. The free weight exercises on the physiotherapy ball included arm reciprocity arm raises, and prone rowing beginning with 1- to 3-pound dumbbells. Exercises were performed for three sets of six to eight repetitions.

Abdominal strengthening

The abdominal muscles were trained through movements of the lower extremities with the entire spine stabilized. The exercises for the abdominal muscles began with proper execution of pelvic tilts, and then progressed to heel lifts, foot lifts, knee-ups, toe taps, and leg slides. Each exercise was performed for three sets of six to eight repetitions. Ankle weights were then added to increase resistance.

Stretching and balance

A pectoral stretch on the physiotherapy ball was performed for thoracic extension and to prevent forward hunched-over posture. A wall press was performed for external rotation of the humerus, sternum elevation and alignment. Stretching exercises for the lower extremities were for muscle imbalances only. Participants were given balance and proprioception (how our bodies perceive our joints in space) training to improve this function. These exercises included single leg balancing, progressing to single leg toe raises, and single leg balancing while simultaneously lowering the torso toward the ground and raising the opposite leg behind the body toward the ceiling.

The Intervention Support Program

Poor adherence to many exercise interventions has often led to potentially biased and conflicting results in exercise studies. A safe, efficacious program is not necessarily sustainable unless strategies are incorporated to keep participants interested, motivated and involved in exercise. Given the common scenario of limited funds, it is understandable that efforts to promote participant attendance and compliance are often a lower priority and underfunded, although they should be considered an equally important component of an intervention program.

The BEST intervention support program was based on social cognitive theory constructs of A. Bandura, Ph.D., Stanford University (5) and encompassed a variety of interpersonal, intrapersonal, and environmental reinforcement strategies to motivate

participants and promote high levels of retention. Both internal and external motivators have been shown to increase adherence with physical activity programs.

The social cognitive constructs underlying the program were: 1) education and skill development, 2) self-efficacy, 3) incentive programs, 4) social support, and 5) modeling.

The primary goals of the intervention support program were to create a fun, social environment and to challenge the women to improve their daily exercise performance. Behavioral change is more likely to occur when individuals clearly perceive the personal and social benefits of the expected behavior. Participation was based on individual improvement rather than competition among participants.

[insert Table 2 here -Social Cognitive Constructs]

Education and Skill Development

Orientation workshops. Before starting the exercise program, all participants attended a posture workshop and a classroom orientation. These workshops were followed by a facility workshop to familiarize exercisers with the facility, the exercise program and equipment, and the BEST trainers.

The BEST book. Each participant received an exercise training manual containing exercise descriptions, photographs of specific muscle groups targeted, proper execution tips, a travel exercise program, motivational poems, and staff and facility phone numbers.

Newsletter. Every three months a newsletter was distributed with information on upcoming events, research updates, healthy recipes, reminders to take calcium supplements, and inspirational poems. The newsletter highlighted individual and cohort accomplishments and included participant spotlight interviews.

Year-end test results. After the year of exercise, a group meeting was held to review results from the baseline, six month, and one-year assessments. Each participant received an extensive written report with her personal test results as well as group results.

Self-Efficacy

Personal best testing. PB testing was performed every two months at the facilities. This testing allowed the participant and BEST trainer to assess progress and adjust training loads accordingly. Participants reported the PB testing was an excellent feedback and motivational tool.

Goal setting/personal contracts. Before beginning the program, each exerciser completed a personal contract reinforcing her commitment to participate in the project for the full year. Short-term and long-term goal setting, and potential barriers and solutions were discussed at this time.

Exercise logs. Each participant filled out an exercise log during their workout that was regularly reviewed by BEST trainers. This log provided on-going feedback to determine load increases and appropriate progression and was used to assess the level of adherence to the exercise program.

Incentive Programs

Two major promotional events were held at the exercise facilities to create a sense of fun and social connection with the BEST trainers and participants. A four-week Murder Mystery game held in January/February encouraged participants to work together to solve a crime using clues earned by attending each workout. A six-week Olympic Team Challenge event was held during the summer months in which participants earned team points for specific components of their workout. Each promotion concluded with a dinner celebration including family, friends and program staff.

As an additional incentive, upon completion of the six-month lab testing participants were presented with a BEST t-shirt.

Social Support

Creating a variety of opportunities for social interaction was a high priority for the study. The events held throughout the year encouraged the participants to develop friendships and alliances beyond exercising and contributed significantly to the high adherence to the program.

Motivational meals. Every two months a "Motivational Meal" dinner was held at local restaurants, or as a potluck with participants bringing a favorite dish.

Educational forums. Four educational forums were held per year to address psycho-social areas of concern for postmenopausal women.

Follow-up support phone calls. Staff and trainers met on a monthly basis to review program compliance. Participants absent for more than two workouts were contacted with a phone call.

BEST yearbook. A yearbook was developed for each exercise cohort that included participant photos, wise words of advise, inspirational poems, home address and phone number and workout schedules.

End of the year celebration. A year-end party was held to recognize the accomplishments of the group and to distribute certificates of completion.

Modeling

Modeling of desirable behavior took place throughout the project. BEST Trainers provided lifting-technique demonstrations during the initial training and regularly checked participants' exercise form for technique and injury prevention. The summer promotion partnered exercisers with one another to encourage participation and develop teamwork.

The women who continued with the program after the first year of exercise provided a strong example of modeling. These women were awarded the title of BEST Masters, to recognize their continued support and participation in the program. The high adherence rates and impressive strength gains by early cohorts established a goal for later cohorts to strive to equal or exceed.

Selection of Community Fitness Facilities

Community fitness facilities were selected based on proximity to participants' home or work (less than five miles), the availability of resistive weight training equipment, treadmills or walking tracks, and stair-climbing availability. The facilities provided a free one-year membership for participants and administrative space for the BEST trainers. In turn, the facilities received recognition for being involved with a university-based study, training of their staff on BEST study protocol, and recruiting the participants as facility members after the first year of exercise was completed.

Results

Participant retention

Retention was defined as the number of women who completed one year of the study to obtain baseline and one-year measurements. Retention rate for exercise participants was 80.2% for 12 months. Out of 177 women assigned at random to exercise, 35 dropped out. The primary reasons for dropping out of the program were due to time constraints and the need to take care of a family member.

Attendance at exercise sessions

Attendance was recorded by the BEST trainers as a measure of participant adherence and was calculated as the percentage of training sessions attended during the 12-month program. Average attendance of participants who completed 12 months of exercise was

75% and ranged from 70% to 78% across six cohorts of women. A high level of calcium adherence was also found.

-insert Figure 1 here- Adherence -

Changes in muscle strength

Muscle strength (1-RM) improved by 28% to 67% in women who exercised and used HRT and 25% to 75% in women who exercised without using HRT. The increases in muscle strength with exercise were statistically significant for all exercises in both groups. Peak isokinetic force was also measured in both exercisers and controls to provide a controlled measure for comparison between groups. Exercisers significantly increased strength whereas the strength of controls subjects did not change.

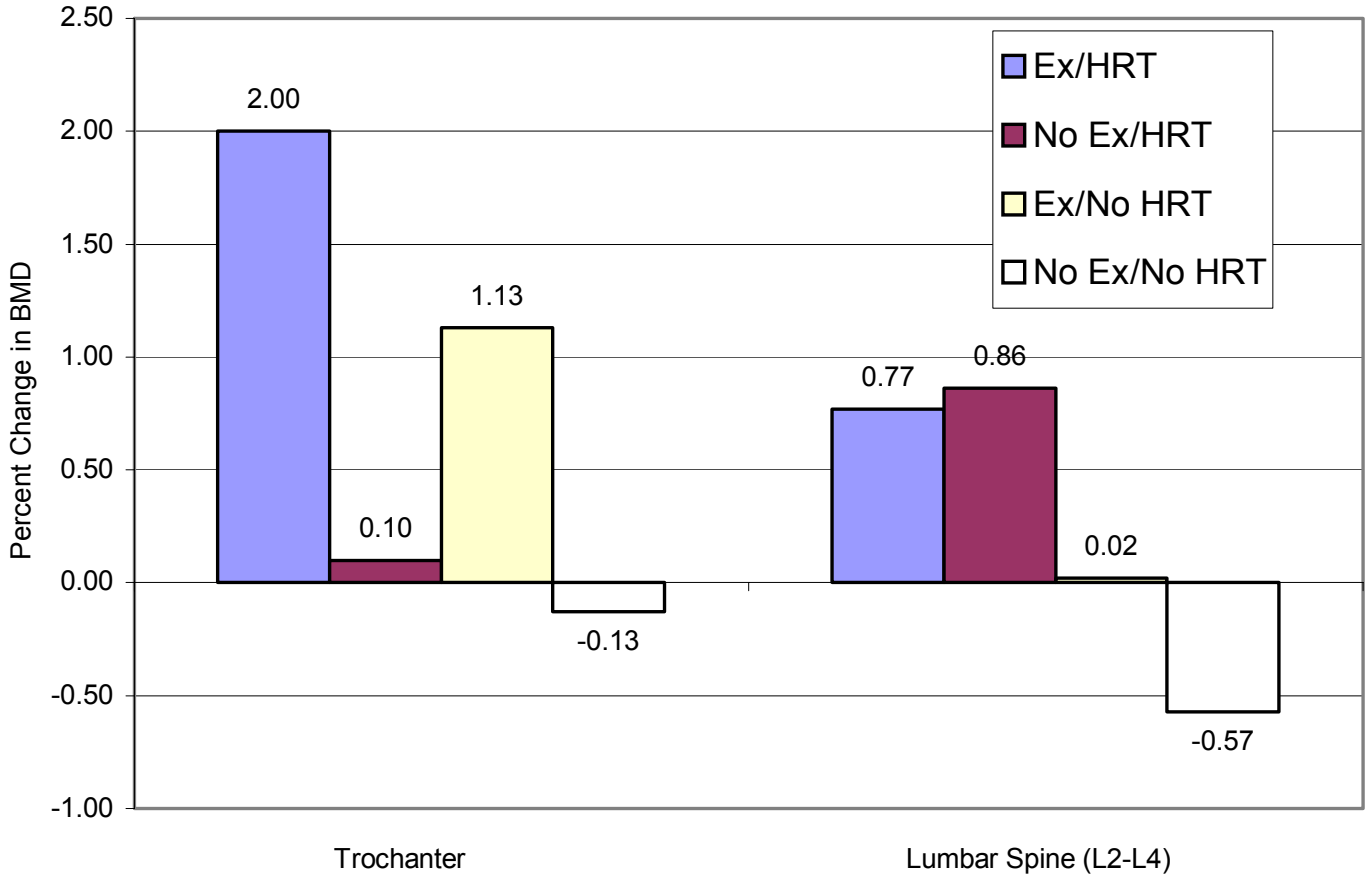
-insert Table 3 here- Changes in Muscle Strength -

Changes in BMD

The changes in BMD after 12 months of exercise were measured by dual-energy X-ray absorptiometry. The responses at two sites (femur and spine) are shown in Figure 2. The BMD increase in the intervention groups compared to the control group ranged from 0.6% to 2.1% from site to site as a result of 12 months of resistance exercise, HRT, or the combination of both. The increases in BMD were similar in magnitude to those demonstrated in other studies with well-controlled, randomized designs in younger and older women. The responses vary by site, with somewhat larger changes in the femur (statistically significant) compared to the spine (not statistically significant). Moreover, there was some evidence of synergistic effects of exercise and HRT, although not at all sites. Although the increases in BMD were relatively small, they represent an important adaptation because the increases occurred at an age when women are usually losing bone. The BEST participants increased their BMD compared with the average loss of one percent per year at this age, when women are not taking calcium, not taking HRT, or exercising. Whether further increases in BMD are possible with continued training is not known, although the excellent retention and attendance of BEST participants will allow us to address this issue with a longer period of follow-up.

-insert figure 2 here-

Figure 2. Percent Change in BMD for Intervention Groups



Long-term follow-up

Upon completion of the initial 12 months, 101 out of 142 (71.1%) of exercise subjects agreed to exercise for another 12 months. Reasons for not continuing with the program included: work-related reasons (n=8), health issues (n=9), cost of membership (n=4), "too busy"(n=4), disliked exercising (n=3), left town (n=2), felt program was too hard (n=2), family obligations (n=2), thought the program took too much time (n=1), wanted to workout at home n=1), lived too far from the fitness facility (n=1), and, did not like the gym atmosphere(n=1).

Lessons Learned

There were several key factors that were consistently mentioned in the year-end evaluations and in participant discussions that contributed to the success of the program.

Participant concern related to health risk

Concern for the risk of osteoporosis was a significant motivator for program sign-up, as was the interest in making a contribution to the body of knowledge on the benefits of exercise for their daughters and granddaughters.

Individualized attention

The program created a variety of opportunities for personalized attention. BEST trainers were available for on-going feedback, motivation and support for the women. This was perceived as a major motivator to maintain involvement in the program.

Removal of barriers

During the first year of the study, each participant was given a one-year facility membership. During the second year, 80% to 100% of the cost of monthly membership was reimbursed based on exercise attendance. BEST trainer hours in the facility were provided at convenient times for the participants to schedule their exercise.

Establishing self-efficacy

The project nurtured a positive environment where participants felt they could be successful in accomplishing the programs' and their personal goals. The exercise program was designed to create early success for each woman; from the first exercise session they developed a positive mindset that they could lift heavy weights and be regular attendees. Many women expressed a high confidence in "honoring my word, when I commit to do something, I do it."

Creating an atmosphere of fun

Opportunities to encourage fun were constantly explored and implemented by the BEST training and lab staff. The participants acknowledged their motivation to show up for each exercise session was enhanced by the enjoyment factor created by the BEST team.

Summary

The BEST intervention program demonstrates how to successfully implement a community-based osteoporosis prevention exercise program for postmenopausal women. The high level of exercise program adherence, calcium supplement adherence, strength improvements and increases in BMD attest to the viability of a rigorous exercise program as an intervention strategy for improving bone health for older

women. The combination of added calcium, regular exercise, and HRT provided the greatest impact on bone health. Greater muscle strength and small significant increases in BMD, if sustained over several years, should reduce the risk of osteoporosis, falls and fractures, as women grow older. The high level of adherence and exercise session attendance rates and the on-going participation by the BEST women even after the conclusion of the efficacy study will make it possible to examine the long-term effectiveness of a rigorous exercise program for maintenance and possibly further increases in BMD and muscle strength.

A comprehensive intervention program that included education, skill development, self-efficacy reinforcement, incentive programs, social support, modeling, and convenient location of community facilities was integral to the success of this program. Given the financial costs associated with osteoporosis, and the need for long-term program adherence to impact on fracture risk, concentrating funds, staff and resources on developing intervention programs similar to the BEST program are not only realistic, but also essential to reduce the impact of osteoporosis on public health.

* The investigators appreciate the generous support of Mission Pharmacal for the donation of Citracal® calcium supplements and the following fitness facilities in Tucson, Arizona: The Fitness Institute of Tucson, University Medical Center Wellness Program, Naturally Women Fitness Facilities, and Metro Fitness.

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Lauve Metcalfe M.S., is the Coordinator of Intervention Programs, Department of Physiology, College of Medicine, University of Arizona, and a co-investigator for the BEST study.
Tim Lohman Ph.D., is a professor, Department of Physiology, and principal investigator for the BEST study.
Scott Going Ph.D. is an assistant professor, Department of Nutrition Sciences and Department of Physiology, and a co-principal investigator for the BEST study.
Linda Houtkooper Ph.D., R.D. is a professor, Department of Nutrition Sciences, and a co-principal investigator for the BEST study.
Dawna Ferriera, B.S., is an exercise trainer for the BEST study.
Hilary Flint-Wagner M.P.H., is an Assistant Research Scientist and project coordinator for the BEST study.
Terri Guido PT, is a physical therapist and owner of SCORE physical therapy center.
Jane Martin, R.N., M.Ed. is a certified counselor and co-investigator for the BEST study.
Jill Wright M.P.H., CSCS, is an exercise trainer.
Ellen Cussler, M.S., is data manager for the BEST study.

Condensed Version and Bottom Line

Osteoporosis is a major threat to Americans. In the United States today, 10 million individuals already have osteoporosis, and 18 million more have low bone mass, placing them at increased risk for this disorder. The results of the BEST study demonstrate that it is possible to implement an osteoporosis prevention program with postmenopausal women that would positively impact bone mineral density and muscle strength. Although the benefits of the community-based osteoporosis prevention exercise program increase in small increments through the years, sustained participation will reduce the risk for falls and fractures brought on by osteoporosis as women age. The BEST program.

Table 2. Social Cognitive Constructs

INTERVENTION SUPPORT PROGRAMS	SOCIAL COGNITIVE CONSTRUCTS
Personal contract	contingency management
Postural analysis	education
Postural education presentation	education
Exercise orientation workshop	skill development, education,
BEST trainer in facility	modeling, social support, skill development, education
Follow-up phone calls by staff/trainer	social support
Personal BEST testing every 2 months	self-efficacy, goal setting
Exercise logs/workout charts daily in facility	modeling, goal setting
Motivational Meals @5 per year	social support, recognition, education
Newsletter (@4/yr)	education, recognition
Educational forums @4 per year	education, social support, skill development
Incentive programs Murder Mystery Summer Olympics	selective reinforcement, social support, modeling, offering incentives, fun
One-on-One Coaching 2-3 sessions per year	coaching/teaching, self-efficacy
Tee Shirts completion of first 6 months	incentives
Monetary Reimbursement 1 year membership to facility	incentives

Table 3. Change in Muscle Strength Assessed by 1-RM in Exercise Groups

Exercise	Ex/HRT (n=71)			Ex/No HRT (n=71)		
	Baseline*	12 Months*	%	Baseline*	12 Months*	%
Leg Press	260±70	420±103	67	259±64	428±98	75
Lat Pulldown	95±18	121±18	30	98±15	122±17	26
Seated Row	80±12	101±17	28	79±11	99±15	25
One Arm Military Press	20±4	27±5	39	20±4	27±5	34
Back Extension	119±27	170±35	47	127±28	168±33	36

*weight in pounds lifted

Figure 1. Adherence to Exercise Three Times Per Week for One Year

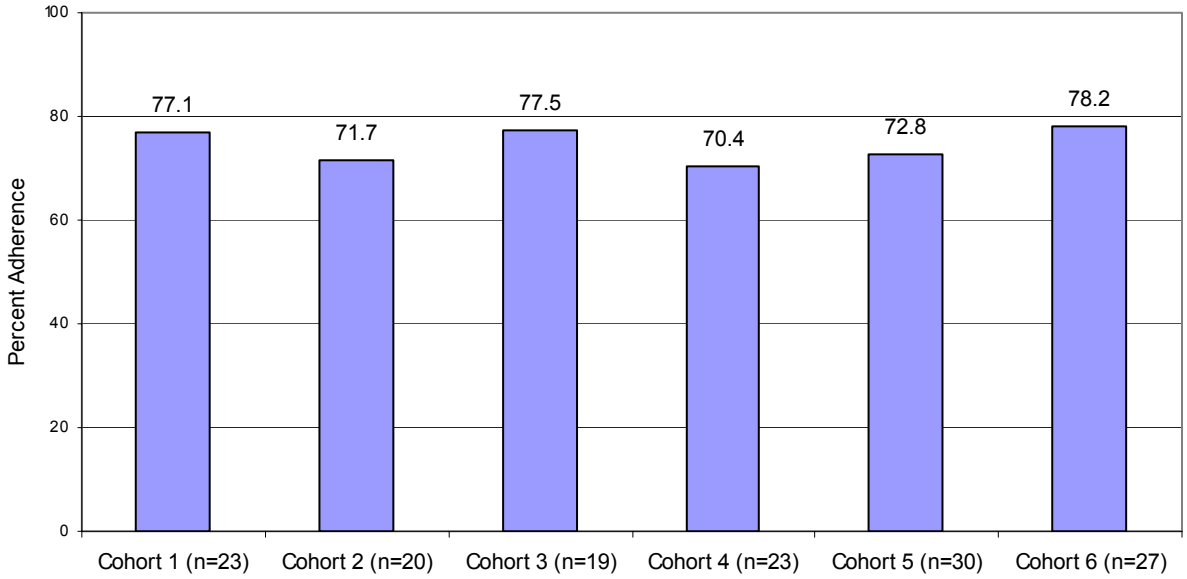

Figure 2. Percent Change in BMD for Intervention Groups