The purpose of this study was to determine if a 5-month progressive-resistance exercise program would affect measures of activities of daily living (ADLs) and functional stability in elderly women. All subjects were ambulatory women, 80 to 93 years old, who lived in assisted-care facilities. Eight exercise and 7 control subjects completed the 5-month study. Exercise subjects participated 3 times weekly in progressive resistance of the lower extremities and upper extremities. ADLs were assessed by the Barthel Index, and functional stability was assessed by timed measures of rising from a chair, walking, and standing, feet together, with eyes open and eyes closed. All subjects were tested at 0, 10, and 20 weeks. Using repeated measures analysis of variance, significant differences were seen only in an overall Group effect ($p < .0005$). The Eyes Open stance ($p = .02$) and Walk ($p = .01$) measures contributed most to this effect. The lack of significance in other analyses may have resulted from low sample size, high variation of scores, initial group differences, or perhaps an ineffective treatment program.
Effects of a Resistance Exercise Program
on Activities of Daily Living of Elderly Women
by
Christine L. DeVries

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APPROVED:

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Dean of Graduate School

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Christine L. DeVries, Author
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Effects of a Resistance Exercise Program on Activities of Daily Living of Elderly Women

Chapter 1

Introduction

Until recently, few long-term exercise programs have been implemented for people with chronic illnesses residing in nursing homes. This population was often thought to be too frail to undergo such physical stress and to be incapable of significant physical improvement. Physical and occupational therapy have been instrumental in rehabilitating older adults after acute injury or illness, but therapy or exercise programs have not targeted long-stay nursing home residents, whose reduced function is often due to deconditioning and multiple chronic illnesses rather than acute events (Mulrow, et al., 1994). The majority of nursing home residents exhibit multiple physical and functional disabilities caused by disease, nutritional inadequacies, sedentary lifestyle, and the normal aging process itself. These conditions lead to decreased strength, range of motion, muscle mass, cardiovascular fitness, and sensory input, and in increased joint stiffness, adipose tissue, edema, pain, and reaction time (Fiatarone, et al., 1994; Fisher, Pendergast, & Calkins, 1991; Hagberg, Graves, & Limacher, 1989; Mulrow, et al., 1994).

Lower extremity strength is important in many daily mobility activities, such as walking, ascending and
descending stairs, and rising from a chair or bed. Decreases in age-related lower extremity strength were cited by Larsson, Grimsby, & Karlsson (1979), by Makrides, Heigenhauser, & McCartney (1985), and by Bassey, Fiatarone, & O'Neill (1992). Muscle weakness in those who are frail and elderly has been correlated with recurrent falls (Tinetti, Speechley, & Ginter, 1982; and Whipple, Wolfson, & Amerman, 1987). Decreased range of motion and increased joint stiffness (during passive movement) due to inactivity, arthritis, edema, and other morbidities of nursing home residents also affect mobility. Hakkinen and Hakkinen (1991) showed that healthy older women were slower than younger women at reaching a maximum isometric force and an equivalent percent of maximum isometric force, which, if the same is true for dynamic muscle contractions, may have a deleterious effect on postural righting responses after loss of balance.

To date, there is equivocal documentation of the effects of exercise programs on nursing home residents, but several studies with healthy older adults have shown improvements in muscle strength and cardiovascular endurance. DeVries laid the groundwork in 1970 with his study of the physiological adaptations of healthy retired men to vigorous exercise, noting significant improvements in areas of strength, body composition, and lung capacities. Frontera, Meredith, O'Reilly, Knuttgen, & Evans (1988) conducted a high-intensity muscle-strengthening program of the lower extremity in healthy older men and cited gains comparable to those of
young men. Hagberg, et al., (1989) studied cardiovascular responses of 70 to 79-year-old men and women, and again cited significant improvements in cardiovascular endurance. These studies and others indicate that the healthy body does not lose the ability to improve certain physiological functions with old age.

Strength-training studies conducted with elderly nursing home residents have shown a variety of results. Some studies indicated no significant change in strength of the subjects, while other studies showed average increases of up to 174% of lower extremity strength. Those studies which employed progressive-resistance exercise programs, as opposed to low-intensity exercise programs, showed the greatest improvements in subjects' strength. One such study (Fiatarone, et al. 1990) also found that a significant (p< .05) improvement in functional mobility accompanied an increase in lower extremity strength. This was evidenced by a mean 48% improvement in tandem gait speed, and by individuals who decreased their reliance on assistive ambulation devices and their reliance on using their arms to assist in rising from a chair.

Despite the positive results, none of these progressive-resistance studies measured activities of daily living (ADLs) to determine whether the subjects' strength gain resulted in a measurable increase in their functional abilities. Only one reviewed study cited an improvement in measured ADLs after an exercise program, which accompanied improvement in
hand-grip strength (estimated as a measure of over-all strength) and chair-to-stand time. There is clearly a need for research in this area, as changes in strength may not be meaningful to the nursing home resident if these changes do not increase his or her independence in daily activities.

Statement of the Problem

The purpose of this study was to measure the effect of a 5-month progressive-resistance strength training program on the activities of daily living (ADLs) and functional stability of elderly women living in assisted-care facilities. The Barthel Index of ADL (Mahoney & Barthel, 1965) was used to assess the ADLs of the subjects, including feeding, dressing, transferring, bathing, toileting, walking, and ascending and descending stairs. An assessment of gait and balance was used to assess timed rising from a chair, timed standing, feet together, with eyes both opened and closed, and gait speed during a 6-meter walk (Tinetti, 1986).

Research Hypotheses

A review of the literature leads to the hypotheses that elderly nursing home residents would improve: (a) functional stability, as measured by timed balance and gait assessments, and (b) ADLs, as measured by an index of ADL, after 5 months of a progressive-resistance exercise program.
Statistical Hypotheses

Using repeated measures analysis of variance (ANOVA), the following statistical hypotheses were proposed for each dependent variable over time.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]

\[ H_1: \mu_1 < \mu_2 < \mu_3 \]

The following statistical hypotheses were proposed between treatment groups.

\[ H_0: \mu_e = \mu_c \]

\[ H_1: \mu_e > \mu_c \]

Operational Definitions

Subjects

For the purpose of this study, all subjects were women over 80 years old who lived in assisted-care residences. Each subject was able to remain standing, with or without support, for approximately 10-minute durations in order to complete exercises. Each subject was cognitively aware (able to understand and follow directions) and each signed her name to indicate informed consent.

ADLs

Each subject's activities of daily living were operationalized by the amount of assistance needed according to the guidelines of the Barthel Index of ADL (Appendix A).
**Functional Tests of Stability**

Functional stability was operationalized by: (a) timed rising, without using arms unless necessary, from a hard, straight-backed armless chair; (b) duration of quiet standing, feet together, with eyes opened and eyes closed; and (c) gait speed during a 6-meter walk on a hard, level surface. The best time of two trials was recorded for each subject.

**Assumptions**

For the purpose of this research, the following assumptions were made:

1. All subjects understood the directions given and put forth their best effort to accomplish the test goals.
2. The subjects' performance during testing was not significantly influenced by medications, illness, or fatigue.

**Limitations**

Some limitations of this study are that the subjects were not randomly selected (they were volunteers), nor were they randomly assigned to exercise and control groups, but those interested in the exercise program were selected for the intervention group. Those not interested in the exercise program, but who were of similar age and ability and who agreed to the testing, were enrolled as control subjects. The intersubject variation and day-to-day intrasubject variation and the lack of availability of subjects (a small sample size) remain limitations in generalizing results to a
larger population of nursing home residents. Furthermore, improvements in strength may not be significant enough to improve functional abilities in people who already have functional deficits.

**Delimitations**

This study was delimited to elderly, cognitively-aware women, living in assisted-care facilities, who did not receive physical or occupational therapy, nor were involved in another regular strength-oriented exercise program. This was necessary to control for confounding factors such as learning effect due to additional strengthening or functional exercises, or the inability to understand or carry out directions and to provide informed consent. The results of this study are delimited to activities of daily living as assessed by the Barthel Index of ADL and by items of Tinetti's test of functional stability as measured by timed rising, walking, and feet-together standing. Results can be generalized to the previously-mentioned population. Generalization beyond the scope of this study, such as to elderly men, to people with severe cognitive deficits, to people with acute disease, or to non-ambulatory people, should involve further collection and analysis of data. Furthermore, results should be noted as those after completion of a 5-month exercise program, and not as an indication of maintenance of any improvement after cessation of the exercise program.
Definitions

The following terms are defined in order to fully understand this study.

Functional Skills

Functional skills, including activities of daily living (ADLs) and instrumental activities of daily living (IADLs), are those which the older adult must be able to utilize in natural environments (home, community) to function independently and to maintain independence.

ADLs. Activities of daily living are the self-care skills which an individual performs daily to maintain health, hygiene, and social acceptance. This includes dressing, bathing, toileting, grooming, getting in and out of bed or chairs, locomoting, and eating. The following items are defined as assessed by the Barthel Index of ADL.

1. Transferring consists of getting into and out of bed.

2. Toileting includes three separately-scored components: (a) bowel control; (b) bladder control; and (c) getting on and off the toilet, handling clothes, wiping, and flushing.

3. Bathing may include using either a tub, shower, or sponge bath, depending upon the preference and the regular routine of the individual or assisted-care facility.
IADLs. Instrumental activities of daily living are those involving higher levels of functioning than basic ADLs. Such activities include shopping, driving or using transport services, cooking, cleaning house, and doing yardwork. These activities were not measured in this study, and are mentioned only to provide a clear definition of ADLs.
Chapter 2
Review of Literature

This chapter reviews published literature which sets the background and establishes the need for this research. First, characteristics of aging adults and of nursing home residents, in particular, are discussed. Changes due to regular exercise observed in both healthy and frail older adults are reviewed. Finally, the uses of ADL assessments of nursing home residents are discussed along with the different types of assessment tools, their validity and reliability, and the particular benefits of the assessment instrument chosen for this research.

Characteristics of Aging

Strength

The population of older adults is extremely heterogeneous with respect to mental and physical health; however, some trends of old age have been well documented in the current body of research. Decreases in age-related lower extremity strength, as measured by isometric and isokinetic torque, were cited by Larsson, Grimsby, and Karlsson (1979); by Makrides, Heigenhauser, and McCartney (1985); and by Bassey, Piatarone, and O'Neill (1992). Muscle weakness in the frail elderly has been correlated with recurrent falls (Tinetti, et al., 1982; Whipple, et al., 1987). Hakkinen and Hakkinen (1991) determined that older women were slower than younger women at reaching a maximum
isometric force and an equivalent percent of maximum isometric force. If this latency is true also for dynamic muscle contraction, it may have a deleterious effect on postural righting responses after loss of balance.

**Joint Range of Motion**

Decreases in active joint range of motion and increases in joint stiffness (passive movement) are common in older adults and especially nursing home residents. These may be caused by inactivity or by a variety of disease processes, such as arthritis, edema, degenerative soft tissue breakdown, and guarding due to pain upon movement. This decrease in range of motion may result in decreased functional ability of the older adult.

**Sensory Input**

As the number of certain sensory receptors declines in old age, and the number of neurons and the efficiency of neuromuscular synapses decrease, older adults are less able to compensate for physical challenges in their environment (Hampton, 1991). Redundant information afforded by different types of sensory receptors is reduced in old age. As a result, older adults have diminished ability to compensate with another sensory system when decreased or conflicting input occurs in a system (Poole, 1991).

In addition, nursing home residents typically have multiple chronic illnesses or functional disabilities (Mulrow, et al., 1994). These may be caused by disease,
depression, sedentary lifestyle, interaction of medications, or nutritional inadequacies. Decreased sensory input in combination with other physiological and psychological factors has an additive effect on human performance.

Falls

Approximately one-third of community-dwelling adults over 65 years of age fall each year; ten percent of these falls result in fractures and other serious injuries. Serious falls are a major cause of death in those over 75 years old, with fall-associated mortality increasing with age (Lichtenstein, Shields, Shiavi, and Burger, 1989). Risk factors for falls include environmental hazards, foot problems, loss of strength or range of motion, use of multiple medications, and dysfunctional balance, gait, or transfers (Anacker & Di Fabio, 1992; Koch, Gottschalk, Baker, Palumbo, & Tinetti, 1986). Studenski, et al. (1994) reported that of the 306 elderly men studied, those at highest risk for falls were those who were both mobile and unstable, as opposed to those who used wheelchairs or those who were stable in mobility. In addition, those more likely to fall were unstable ambulators who took more risks and those with lower ADL scores (using the Katz ADL scale). Tinetti (1986) reported that fear of falling was also correlated highly with the number of falls experienced.

Maki, Holliday, & Topper (1991) determined that older adults who feared falling had a shorter stance duration, with both eyes open and eyes closed, than their peers with less
anxiety of falling. Anacker and DiFabio (1992) concluded that nursing home residents with a recent history of falling had greater postural sway (measured by a stationary force plate) in quiet stance than non-fallers. After testing 100 elderly men and women with Tinetti's Gait and Balance Assessment (Tinetti, 1986), Topper, Maki, and Holliday (1993) concluded that the balance tests were predictive (p=.03 to .009) of 3 of the 4 types of falls studied, especially those involving movement of a person's center of mass beyond his base of support (e.g. via collision, turning, transferring, or leaning too far). Due to findings that the risk of falling increases linearly with the numbers of abnormalities in gait and balance, Tinetti (1986) suggested that every exercise-based intervention may increase mobility in the elderly, thus decreasing the risk of falling.

Strength and Functional Changes in Older Adults After Exercise Programs

Studies with Healthy Subjects

Several studies with healthy older adults have shown improvements in muscle strength after an exercise program. In 1970, deVries published results of one of the first research exercise programs using older adults. He cited significant improvements in certain physiological factors of 112 retired, healthy men, aged 52 to 88, after an exercise program. He noted significant improvements (p< .05) in oxygen pulse, vital capacity, and minute volume at HR= 145
beats/minute, which represents 90% of maximum heart rate for this age group. (For safety reasons, the researcher chose not to test older adults at 100% maximum HR.) After 6 weeks of exercise, including warm-up, jogging, stretching, and aquatics for one hour, 3 times per week, subjects measured significant improvement over the control group in arm strength and physical work capacity and significant decreases in body weight and percent body fat. The percentages of change were similar after 42 weeks of exercise; however, results were not statistically significant, as only 8 of the 68 exercise subjects completed 42 weeks of exercise, due to subjects' staggered initiation times.

DeVries (1970) determined that the previously least-active subjects made the greatest gains, regardless of prior training experience. This finding indicates two commonly-held modern principles of exercise. First, older adults can greatly benefit from exercise, regardless of prior activity levels. Second, health benefits of exercise as a young adult may not benefit an individual at an older age if regular exercise is not maintained.

Frontera, et al., (1988) conducted a high-intensity muscle-strengthening program in healthy older men and cited gains comparable to those of young men. After the 3-month isokinetic weight training program, the subjects showed significant increases in strength of knee flexors and extensors, using the 1-repetition maximum (1-RM) test; in thigh muscle cross section (10-11%), using a CT scan; and in
muscle fiber area, by biopsy. The three muscle biopsies taken from the vastus lateralis muscle of each subject—before the exercise program, at midpoint, and after the program—evidenced progressive increases in slow-twitch (type II) muscle fiber area throughout training. In addition, urinalysis evidenced an increase in actomyosin protein turnover, which indicates amino acid synthesis used for actin and myosin proteins in the muscle. The researchers concluded that the capacity to increase muscle mass is retained in old age, and that improvement in strength is partially due to muscle hypertrophy.

Similar studies showing comparable strength gains in healthy elderly subjects, coupled with the desire to improve physical functioning in frail nursing home residents who do not receive physical therapy benefits, provided the impetus to test exercise programs on this population. Studies range from mild calisthenics programs, using no weight resistance, to high-intensity strength and endurance training. Program protocols and results vary greatly.

Studies with Nursing Home Residents

Lower-intensity programs. A study by Mulrow, et al. (1994), provided 4 months of physical therapy with bimonthly assessments of elderly nursing home residents who had lived in the nursing homes studied for over 3 months. The 194 eligible residents (70% women) were divided into two groups: intervention (PT) and control (friendly visit). To control
for gains due to tri-weekly socialization of the intervention group, the control group received one-on-one visits, three times weekly, where physical exercise and "cognitive and psychosocial interventions, such as puzzles and elicitation of feelings" (p. 521) were avoided. These control sessions usually involved reading to the residents.

The intervention group received training in passive and active range of motion exercises, endurance activities, motor control activities (balance and coordination), bed mobility skills, transfers, gait training, and wheelchair propulsion, as deemed appropriate for the individual. Resistance exercises were discontinued as the therapist judged that the individual was strong enough to focus on more functional training.

At the conclusion of the program, physical therapists saw modest improvements in mobility (15.5%, p=.01) of the intervention group over the control group. Time to perform simple motor tasks such as sitting up and transferring improved, and less use of assistive devices for such tasks was required, overall. No significant improvements in other areas of physical performance, self-perceived function, or ADLs (measured by the Katz Index of ADL) were seen. These limited results may have been due to chronic disabilities of the subjects; 75% had at least 3 comorbid conditions, with 25% having more than 5 comorbidities. Another possible reason for the lack of improvement of subjects is the relatively low intensity of the program.
Another low-intensity exercise program (McMurdo & Rennie, 1993) showed slightly better results. In this study, 45 nursing home residents (80% women), age 63 to 91, participated in seated exercises in which they moved joints of the upper and lower body through the entire range of motion, progressing to sustained (isometric) contractions without resistance. The exercise sessions were held twice a week for 45 minutes, 10 minutes of warm-up and 35 of repetitive exercises with no resistance. As the study progressed, the number of repetitions was increased and muscle contractions were sustained for longer periods of time. The control group participated in twice-weekly reminiscence sessions with peers. The researchers measured pre- and post-tests of postural sway, grip strength, knee flexion and extension, spinal flexion, ADLs (using the Barthel Index), height, weight, psychological measures (using the Geriatric Depression Scale, Life Satisfaction Index, and the Mini-Mental State Exam), and chair-to-stand time. At the end of 7 months, the exercise group showed significant improvement in measures of grip strength ($p < .02$), spinal flexion ($p < .001$), chair-to-stand time ($p < .001$), and activities of daily living ($p < .05$), while the control group deteriorated in these measures. Though both groups improved in the self-rated depression scale, only the exercise group improved significantly. Significance was seen in no other measurement. One limitation of this study was that the sole observer knew the group assignments of the participants, so
there was possible observer bias. However, these two studies, citing different results in measures of ADLs, are the only ones published which have measured the effects of an exercise program on ADLs in this population. This justifies the need to study ADLs during a more intense, progressive-resistance exercise program.

Higher-intensity programs. Though intense exercise has long been avoided for the nursing home population as a safety precaution (and, likely, lack of funding and equipment), recent studies have shown benefits from intense strength training. Fisher, et al., (1991) studied 18 frail and functionally-dependent residents (80% women) in a veterans' nursing home. Eligible subjects were required to be able to walk at least five steps, flex their knees 45 degrees, transfer to the exercise bench, and be free of severe paranoia, metastatic malignancy, or uncontrolled heart disease. The 14 subjects who completed the study had varied and multiple chronic diseases and were taking an average of four medications each.

The researchers measured knee extension strength because of the quadriceps muscles' importance in functional mobility activities. Initial testing consisted of a) isometric contractions (contractions during which the joint is not moved) at three different hip angles (90, 135, and 180 degrees) and a 90 degree knee angle, and b) speed of quadriceps contraction, measured by rapid knee extension from 90 degrees, with a small weight. The muscle rehabilitation
program consisted of 6 weeks, 3 times per week, and started with isometric contractions and slow knee extensions, without resistance, through the entire range of motion. At the third week, isometric contractions were continued and isotonic contractions (with resistance) at the three hip angles were added. The rate of increase in resistance was individualized, with a goal of 10% increase of the initial strength measurement each week, up to 50% of the initial value.

After completion of the training program, there was a significant increase in maximum isometric force of knee extension for the 10 women and 3 of the 4 men. Values ranged from 0% to 30% improvement; the coefficient of variation averaged .61. There was also a significant improvement in muscle endurance (measured by the force-time integral) for the women and 3 of the 4 men. Again, a large standard deviation (coefficients of variation averaging .73) demonstrated large variability between subjects.

All subjects who completed the program said it was enjoyable and attended an average of 90% of the sessions. Two-thirds of subjects felt "better" and claimed that they could walk, stand, and rise from a chair more easily. The nursing home staff believed that, in general, the participants became more independent and active. Four months after the program, 9 of the 14 subjects agreed to a reevaluation. Maximum isometric force for knee extension at
the three angles was not significantly lower at this time
($p<.05$).

Another high-intensity strength training program
evaluating quadriceps strength showed similar results in
lower extremity strength (Fiatarone, et al. 1990). Subjects
for this study were ten 86- to 96-year-old men and women who
required minimal to moderate assistance in activities of
daily living. Four subjects had evidence of
undernourishment, as they were 72%-88% of ideal body weight.
Most subjects had excess adipose tissue, with CT scans
showing that muscle accounted for an average of only 31% of a
cross-sectional area of the mid-thigh.

Pre- and post-tests consisted of body composition, using
CT scans of the non-dominant thigh; functional mobility,
tested by chair-standing and gait observations; and
quadriceps strength, tested by a one-repetition maximum (1-
RM) test on a standard weight-and-pulley system. The initial
phase of the 8-week training program used 50% of the 1-RM
value as the training weight, then 80% maximum during the
second week, or as tolerated by the individual. The 1-RM was
measured every two weeks, and the weight protocol adjusted
accordingly, as just described.

Nine of the ten subjects completed the study with 98.8%
attendance. Strength gain ranged from 61% to 374% over the
8-week duration, averaging 174% +/- 31% ($p<.0001$). Strength
gain was progressive throughout the program and had not
plateaued by week 8. Muscle area increased in 5 of 7
subjects CT-scanned; however, subcutaneous or intramuscular fat areas did not change significantly. This is likely because the subjects did not participate in aerobic exercise, which metabolizes fat more readily than strength training. An increase in mobility was seen by a 48% improvement in tandem (heel-to-toe) gait speed, though no improvement was seen in habitual gait speed. There was no significant change in mean functional status, but a few individuals showed marked improvement. Two subjects who had previously used canes to ambulate no longer used them by the end of the training session, and one of three subjects who could not initially rise from a chair without using arms was able to do so by the end of the study. After the study, however, all subjects resumed their sedentary life-style. In contrast to the independent activity changes seen by Fisher, et al. (1991), the 7 subjects in this study retested for the 1-RM after four weeks showed a significant (32%) loss of maximum strength.

Sauvage, et al. (1992), conducted an aerobic exercise training program 3 times per week for 12 weeks in attempt to improve gait and balance in 12 nursing home subjects. Unlike the previous two studies, Sauvage and colleagues studied a control group as well as the intervention group. Pre-tests and post-tests consisted of manual muscle testing, Tinetti mobility testing, isokinetic strength testing of the quadriceps and hamstrings muscle groups (using the Cybex II isokinetic dynamometer), exercise stress testing, and gait
and balance testing. Each exercise session included a warmup of 3 to 5 minutes of leisurely cycling, aerobic exercise for 20 minutes on a cycle ergometer, strength training, and a warmdown of 3 to 5 minutes cycling. Aerobic exercise was performed at a target heart rate >70% of the stress-tested maximum heart rate, which was monitored regularly. Strength training was performed on hip flexors, extensors, abductors, and adductors, knee extensors, and ankle plantarflexors, as these muscle groups were seen as primary in mobility.

All ten men completing the program increased the amount of weight lifted in 10-RM tests, averaging 99% increases for hip muscle groups, 81% for knee extensors, and 80% for ankle plantarflexors. The mean increase in the Tinetti mobility test of +3.37 was significant (p<.05), with each subject scoring higher in the post-test than in the pre-test. The greatest results of the balance testing were in those tests which involved strength as well as balance, such as rising from a chair. No improvements were seen in VO2max or static balance. None of the control group subjects improved significantly at the end of 12 weeks in any variable except combined hamstring strength (p<.05). No indication was given to evaluate whether the results were significant enough to show an increase in functional activity.

Noting that many elderly nursing home residents showed evidence of undernutrition, a study by Fiatarone, et al. (1993 & 1994) combined a nutrition supplement with a strength training program. One hundred subjects were divided into 4
equal-sized study groups: strength training only, nutrition supplement only, both strength training and nutrition supplement, and control. Ninety-four subjects (63% women) completed the study. The control group received a placebo supplement and placebo activities to control for increased socialization of the exercise groups. The subjects averaged 87 years old. Eighty-three percent required a cane, walker, or wheelchair, and 66% had fallen within the past year; their physical activity levels were about 25% of that recorded by sedentary young adults. The most prevalent chronic conditions included arthritis, pulmonary disease, osteoporotic fracture, hypertension, and cancer.

Pre- and post-testing consisted of body composition, including CT scans of the mid-thigh, and a 1-RM test for hip and knee extension. The exercise-group subjects participated in high-intensity progressive resistance training of the hip and knee extensors 3 times per week for 10 weeks. Resistance was set at 80% of the 1-RM value, to start, and increased at each session, or as tolerated by the individual. Strength testing was conducted every 2 weeks to re-establish a maximum resistance value, a similar protocol to that used by Fiatarone, et al., (1990).

The exercisers showed significant improvements in all muscle strength tests and increased cross-sectional muscle area. Subjects who were initially the weakest, but had less muscle atrophy than their peers, had the greatest benefit from the strength training program. The dietary supplement
groups increased significantly in body weight, but did not change significantly in fat to muscle ratio. The dietary supplement did not significantly effect the variables of muscle strength and mobility (p-values ranged from 0.24 to 0.84).

The functional mobility of a few individuals changed over the course of the study: four subjects in the exercise group who previously used a walker required only a cane after the study, and one non-exerciser who used a cane before the study digressed to a walker by the end of the 10 weeks. In addition, mean gait velocity increased in the exercisers by 12% and decreased in the nonexercisers by 1% (p= .02), and stair-climbing power improved in the exercisers by 28% compared to 4% in the nonexercisers. As seen in the Fisher, et al., (1991) study, nursing home staff perceived increased levels of spontaneous physical activity in several residents in the exercise group. One cannot assume, however, that these observations were reliable accounts of actual activity increases, as the staff surely were aware of which subjects were participating in the exercise program.

Though results of these strength-training studies vary greatly, a few well-conducted programs resulted in significant strength gains in elderly nursing home residents. These studies have shown that strength values of nursing home patients initially average 50% that of healthy age-matched norms, so average improvements less than 100% will fail to raise the nursing home resident to the mean value of healthy
peers. After the exercise program, improvements raised the overall mean strength of these subjects to 65% normal, seen by Sauvage, et al., (1992) and 80% normal, seen by Fiatarone, et al. (1990). The importance of these strength improvements cannot be evaluated separately from functional improvements. Liem, Chernoff, and Carter (1986) state that even small functional gains are frequently important to the patient, as these gains can make a difference in the amount of independence achieved.

Independence is important for the attitude and mental health of the individual, as well as for the time commitment of the nursing home staff. A more independent resident takes less staff time. A study of bed activities of nursing home residents (Schoening, et al. 1965) found that the most severely involved residents required an average of 5 position changes every 24 hours. One or two staff persons required approximately 10 minutes to accomplish the task each time; therefore, roughly 50 minutes of staff time each day was spent on bed positioning for each dependent patient. If a strength-training exercise program can improve the strength and functional ability of an older adult living in a nursing home, this can increase a person's independence.

Review of Assessment Tools

Correlation Between Mobility and ADL Measures

Recent studies indicate that older individuals' scores on ADL measures correlate highly with their scores on
mobility measures. In a study of 31 elderly residents (71% women) of an assisted-care facility, Berg, Maki, Williams, Holliday, and Wood-Dauphinee (1992) found that the mobility items of the Barthel Index correlated well with Tinetti's Balance Sub-scale ($r = .76$, $p < .001$). Guralnik, et al. (1994) and Guralnik, Ferrucci, Simonsick, Salive, & Wallace (1995) measured ADLs (using the Katz ADL scale) and gait and balance (using some of Tinetti's measures) of, respectively, 5174 and 1122 community-dwelling older adults. They found that better times on the mobility skills related to relatively greater independence in ADLs. Those subjects who scored relatively higher on a summary performance score (Guralnik, et al. 1994), composed of ADLs, a half-mile walk, and stair climbing, were less likely to have died or to have moved to a nursing home at follow-up, nearly 1.5 years later. Those subjects with lower baseline scores of physical performance (Guralnik, et al. 1995) were associated with greater decline in these measures 3 years later.

Siu, et al. (1993) studied 155 new residents of a long-term care institution using measures of health, ADLs, physical performance, cognitive factors, and social factors. Compared to all other measures, the correlation of self-reported lower extremity mobility was highest with Tinetti's performance-based gait and balance, and self-reported ADLs (from the Katz scale) correlated nearly as strongly with the gait and balance scores. From this study, the researchers determined that the self-reported physical functioning had
acceptable convergent and discriminant validity when compared to observed performance. In addition, this study of elderly individuals with normal to mildly impaired cognitive function showed similar convergent and discriminant validity to that observed in studies with younger subjects. Convergent validity examines the difference between self-report and observed performance of a skill. Discriminant validity measures the extent to which correlation between self-report and observed performance of related aspects of functioning exceed their correlation with measures of other aspects of functioning.

**ADL Assessment**

The ADLs of the subjects involved in high-intensity exercise programs need to be reliably assessed, as an increase in strength is not meaningful for this population unless it is accompanied by an improvement in functional ability. ADL assessments vary in length from approximately 15 to 90 minutes, in the manner of scoring, in the use of standardized equipment, and in the presence of published validity and reliability. The Barthel Index (BI) was chosen for this study, as it is relatively quick and easy to administer. It is designed to be measured in the individual's home environment, and it requires no special equipment. It includes both numerical scoring and qualitative discussions of the scores (see Appendix A, The Barthel Index). Anyone who works with residents of nursing homes can be easily familiarized with the test, and it can be
accurately and quickly scored by anyone who adheres to the definitions outlined by Mahoney & Barthel (1965) and Collin, Wade, Davies, & Horne (1988). The BI has been deemed valid and reliable (Filiatrault, Arsenault, Dutil, & Bourbonnais, 1991; and Wade & Collin, 1988).

The index was devised and utilized at a hospital to measure improvement during inpatient rehabilitation. The creators of the BI concluded that the index was most effective with stroke patients, but it has been used effectively in a variety of research and rehabilitation settings (Granger, 1979). It has demonstrated good inter-rater reliability (Collin, et al. 1988) and predictive validity (Filiatrault, et al. 1991; Wade & Collin, 1988). The latter refers to its ability to predict length of hospital stay and assignment--which rehabilitation patients will be able to successfully return home, and which will be referred to an assisted-care facility (Filiatrault, et al. 1991).

The BI was originally designed as a 100-point scale in 5-point increments (Mahoney & Barthel, 1965). However, Collin, et al. (1988), noting that this scale gives a misleading impression of accuracy, thereby changed the scoring to a 20-point, 1-point increment scale. They also modified some of the scoring guidelines to clarify vague areas.

Gresham, Phillips, and Labi (1980) compared scores of 148 stroke rehabilitation patients, using 3 common indexes of
ADL: the Barthel Index, the Katz ADL scale, and the Kenny Self-Care Evaluation. The authors found a high degree of agreement among the scores derived by all 3 indexes. They preferred the BI because it used numerical scoring, it was sensitive to change in individuals' performance, and it covered all areas of ADLs evaluated in longer ADL scales.

Summary

Effective exercise programs for frail elderly people are difficult and time-consuming to administer. Because of the extreme heterogeneity among individuals, individualized training is often necessary. The elderly must be closely monitored for injury, proper technique of training, heart rate, and blood pressure. Exercise programs for this population have high drop-out rates due to morbidity and mortality, as witnessed in the reviewed literature. Many of the studies reviewed in this paper had small sample sizes, and many had no control group, which makes generalization of results difficult. However, these papers reveal that chronically ill, long-term nursing home residents can benefit from carefully-implemented and well-documented exercise programs. The greatest effect on strength gains has been seen by high-intensity, progressive resistance programs. The literature suggests eight weeks as the minimal length of time necessary to see significant results in this population, and a longer period must be implemented to attain maintenance of exercise benefits. Frontera, et al. (1988) and Sauvage, et al. (1992) stated that specificity of training is important:
dynamic strength programs showed greater gains in dynamic strength than isometric strength, and strength training programs showed greater gains in strength measures than in cardiovascular endurance measures, and vice versa. By choosing exercise activities that attempted to improve strength of the lower extremities, the researchers demonstrated the importance of maximizing improvements in the subjects' functional abilities, beginning with mobility. Significant improvements have also been seen in cardiovascular endurance of healthy elderly people (Hagberg, Graves, & Limbacher, 1989) and varied results have been seen in cardiovascular training of frail nursing home patients (Naso, Carner, Blankfort-Doyle, & Coughey, 1990, and Thompson, Crist, Marsh, & Rosenthal, 1988). A few of the reviewed studies have indicated functional mobility improvements after exercise programs, and one study indicated an increase in ADLs after a low-intensity exercise program.

Though there is currently little evidence of the effect of exercise programs on ADLs of nursing home residents, these studies indicate that such programs may be an important element in preventing further disability in this population. Regular exercise has a great potential to increase, or at least better maintain, function of these individuals, which will increase their life options and independence, as well as saving time of the nursing home staff who assist them with daily activities.
Chapter 3
Methods and Procedures

The subjects and instruments involved in this study are described in the following pages, as well as the exercise progression, the experimental design, and the procedures for data analysis.

Subjects

Subjects for this study were 15 women (7 in the control group and 8 in the exercise group) over 80 years old who lived in assisted-care facilities. Every subject who completed the program was ambulatory; 2 exercise and 3 control subjects used walkers, 2 exercise and 2 control subjects used canes, and 4 exercise and 2 control subjects used no assistive device, other than railings, to ambulate. All subjects were able to stand, with or without a support device, for 10-minute durations in order to complete the exercises. Each was cognitively aware, able to understand and follow verbal directions given with demonstration. Each subject read, or was read, the informed consent document and signed her name to indicate consent (Appendix B, Consent Form). Subjects were involved in no other resistance exercise program before or during the intervention period, though some subjects in each group occasionally participated in range-of-motion exercises in their residences.

Subjects were recruited by the researchers with assistance from activity directors, physical therapists, and
administrators of local assisted-care facilities. Subjects were screened to determine if they met the stated criteria; screening included conducting the standing exercises, without weight, to determine subjects' ability to complete the exercises. (See Appendix C, Oregon State University Institutional Review Board approval.) To maintain confidentiality, each subject was assigned a code number used in recording and analyzing data.

**Instruments**

**Barthel Index**

The Barthel Index of ADL (Mahoney & Barthel, 1965) was used to assess each subject's activities of daily living. The Index consists of the following components: feeding, bed/chair transfers, grooming, toileting, bathing, walking on a level surface, ascending and descending stairs, dressing, and bowel and bladder control. It has been deemed reliable, as it measures all 10 activities usually considered essential parts of any longer ADL assessment (Wade & Collin, 1988). The index weighs heavily on mobility items, which made it an attractive option when studying the effects of exercise on strength and mobility, as well as ADLs. The 20-point scale, reviewed previously, was adopted for this study. Each individual component was scored according to the amount of assistance (physical assistance or supervision) required to complete each task. Please refer to Appendix A for the point system and the qualitative guidelines for scoring. The
primary investigator assessed the subjects in the daily activities of walking and ascending and descending stairs. Daily activities of dressing, grooming, getting in and out of bed, eating, bathing, toileting, and bladder and bowel control were assessed by a primary caregiver.

**Functional Stability**

Functional stability was measured by using 4 components of Tinetti's Performance-Oriented Assessment of Mobility of elderly subjects (Tinetti, 1986). Timed measures of (a) rising from a chair, (b) side-by-side standing with eyes opened, (c) side-by-side standing with eyes closed, and (d) walking 6 meters were taken in the subjects' home environment. Two trials of each were allowed, and the best time of each task was recorded. The first measure of functional stability involved the subject seated in a hard, straight-backed chair, and rising to standing then returning to sitting without using the arms. If the subject could not first rise without use of the arms, she was allowed to use her arms only as much as needed to push herself up out of the chair. This was allowed in order that a score could be recorded for these subjects; a score of 0 was not feasible for failure to rise without arm use, as lower scores (faster times) were "better" scores for this measure. Side-by-side standing involved the subject standing, without using external supports, with the medial aspects of her feet touching. The duration she was able to stand without stepping, swaying "abnormally," or grabbing an object for
support was recorded first with eyes open, then with eyes closed. Tinetti (1986) did not quantify "abnormal" sway, which made this measure susceptible to observer variability. To attempt standardization, the primary investigator held her cupped hand approximately 1.5 inches from the subject's shoulder during testing. If the subject swayed enough to touch the tester's hand, the time was stopped and recorded. Lastly, her time to complete a 6-meter walk on a smooth, level surface (such as linoleum, concrete, or very low-nap carpeting) was recorded. The subject could use a cane or walker, according to her usual mode of ambulation. For each task, a human spotter was present to promote safety. If the task could not be attained on or near the testing day due to prolonged illness, the mean group (exercise or control) score was recorded for that task at that time. This procedure was necessary to modify the mobility scores (but not ADLs) for two control subjects, DP and IH, at the mid-point test (see Raw Data, Appendix D). This common procedure allowed the subjects to be included in the analysis without altering the group mean scores.

**Procedures**

All potential subjects went through orientation, either in a group or individually, in which the study was explained and testing was completed to determine eligibility for the program. Principles of progressive-resistance exercise training were implemented for this study. Loading of the
lower extremities was individualized, based on the weight of each subject. Thus, benefits could be maximized and risk of injury reduced.

**Exercise Group**

The exercise sessions and functional assessments were conducted by a team of investigators in public meeting rooms at the subjects' residence. Assessments were conducted for both groups before initiation of the exercise program, at midpoint, and at the conclusion of the program. Exercises were conducted in small groups, 3 mornings per week (Monday, Wednesday, and Friday), for 25 to 45 minutes each session. Each exercise session began and ended with a 5-minute warm-up and cool-down of seated movement and stretching. Subjects were allowed short rests between each set of resistance exercises to control fatigue. The investigator provided occasional feedback to subjects in order to ensure proper, safe technique, although verbal feedback was gradually decreased in order to diminish subjects' reliability on external feedback.

**Lower extremity exercises.** Lower extremity exercises were done while standing to increase loading and included raising from a chair, calf raises, half-squats, lunges, and straight-leg hip extension and flexion. During all exercises, subjects wore a body vest with special pockets so that additional weights could easily be increased during the 5-month training period. Each vest pocket held 0.5-pound
weights. The first two weeks of the exercise program, no weights were added to the body vest; this time was used to accustom the exercise subjects to the vests and the exercise protocol before weights were added. During subsequent weeks, weights were added to the vests at 0.5-pound increments to load the spine and lower extremities (Table 1).

Table 1

<table>
<thead>
<tr>
<th>Exercise Progression: Lower Extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>1-2</td>
</tr>
<tr>
<td>3-4</td>
</tr>
<tr>
<td>5-6</td>
</tr>
<tr>
<td>7-8</td>
</tr>
<tr>
<td>9-10</td>
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<tr>
<td>11-12</td>
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<tr>
<td>13-15</td>
</tr>
<tr>
<td>16-18</td>
</tr>
<tr>
<td>19-20</td>
</tr>
</tbody>
</table>

Upper extremity exercises. Upper extremity exercises included bicep curls, wrist curls, side-arm raises, horizontal rows, and tricep push-backs using hand weights. The exercises were done without weights the first two weeks; weights were increased by 0.5-pound increments through week 13, then by 0.25-pound increments thereafter (Table 2). Many
subjects began to have shoulder soreness and difficulty completing side-arm raises by week 13, so the weight for that exercise was lessened to 1 pound and maintained there for the remainder of the program, while subjects increased only repetitions. Upper extremity exercises were done from a seated position, one arm at a time.

Table 2

Exercise Progression: Upper Extremity

<table>
<thead>
<tr>
<th>Week</th>
<th>Repetitions</th>
<th>Sets</th>
<th>Weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>3</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>3-4</td>
<td>3</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>7-8</td>
<td>6</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>9-10</td>
<td>6</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>11-13</td>
<td>8</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>14-15</td>
<td>4</td>
<td>2</td>
<td>2.25&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>16-18</td>
<td>6</td>
<td>2</td>
<td>2.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>19-20</td>
<td>8</td>
<td>2</td>
<td>2.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Exception: A 1-lb. weight was used for side-arm raises during these weeks.

Abdominal exercises. Abdominal exercises involved seated bent-knee raises, with controlled breathing, without additional resistance. Subjects began with one set of three repetitions the first two weeks, increasing sets and repetitions as described for the lower extremity progression.
Control Group

Control subjects were assessed for ADLs and functional stability as described previously, on the same days as the exercise subjects or as near as possible to those days. To control for any changes in function due to a Hawthorne effect, the investigator attempted to visit the control subjects weekly.

Experimental Design

This study involved a quasi-experimental design to analyze the effect of a progressive-resistance exercise program on activities of daily living and measures of functional stability. Measurements of the dependent variables were taken 3 times: prior to initiation of the 5-month intervention, at midpoint, and just after the intervention period. With initially only 11 subjects interested in the exercise program, randomization of subjects into groups was not feasible. Therefore, the 11 women interested in participating in the exercise program were enrolled as exercise subjects, while 10 women of similar age and functional ability and who agreed to the testing procedures were recruited and enrolled as control subjects. These 21 subjects completed initial testing; however, data analysis was completed with 8 exercise subjects and 7 control subjects. All testing, exercise sessions, and control group socialization sessions occurred late in the morning to
control for daily variation due to medications or changes in levels of awareness or fatigue.

Treatment of Data

The SPSS 6.0 software program (Windows) was used to analyze the data. A 2 x 3 (treatment groups x time) analysis of variance design was chosen for this study. Two levels of independent variable (control group and exercise group) were measured 3 times on each of the 5 dependent variables (the Barthel Index of ADL, chair standing, side-by-side standing with eyes open, side-by-side standing with eyes closed, and a 6-meter walk). Repeated measures analysis of variance (ANOVA) allowed the investigator to control for individual differences among subjects and accounted for smaller sample sizes.

Transformation of Variables

Since a repeated measures design involves multiple observations of each subject, special procedures must be used to account for dependence between observations. Multiple t-tests would not be statistically independent, as the same means are used in overlapping combinations. Therefore, the repeated measures ANOVA computer program transforms the variables into statistically independent "contrasts." For this study, polynomial contrasts were used in order to examine data trends over time. The first transformed variable, the constant, is the average response over all times. The null hypothesis that the average response is
equal to 0 is based on this constant variable. The next two transformed variables examine the linear trend and the quadratic trend over time. The repeated measures design exhibits smaller error than multiple t-tests by accounting for dependence between observations, and it allows a single test for differences between groups (SPSS Inc., 1994, pp.110-112).

Assumptions

Assumptions associated with ANOVA include random selection and assignment of subjects; since this was not met for the current study, actual power may be reduced from the calculated value. Another assumption of the univariate analyses in repeated measures ANOVA is that of sphericity: that correlations of variance between test sessions are not significantly different (SPSS Inc., 1994, p. 116).

One problem associated with repeated measures designs involves subjects improving at the task (practice effects) as a result of repeated testing (Thomas & Nelson, pp.154-155). This was not considered a significant concern for this study, as test periods were 10 weeks apart, and all tests involved life activities in which the subjects participated regularly.

A medium effect size was expected for this study, and an alpha-level of .10 was set as significant. A large effect size could not be expected with this population, according to the variation of results of the reviewed literature, and because this study implemented a conservative progressive-resistance intervention due to the age of the subjects. In
addition, the assessment tools were deemed not sensitive enough to accurately detect a small effect size, so a medium effect size was deemed most appropriate. According to Barcikowski and Robey (1985), a repeated measures design with this effect size and alpha-level should have 11 subjects in each treatment group in order to establish adequate power. Due to attrition of 6 subjects in this study, leaving groups of n=8 and n=7, the power was likely too low to detect significant changes. This will be further discussed in the next chapter.
Chapter 4

Results

All subjects tested were caucasian women between 80 and 93 years old (mean = 84 yrs.) who lived in assisted care facilities. Overall, the exercise subjects participated in 87% of 58 exercise sessions over 20 weeks. Excluding the one subject who participated in only 55% of sessions, the rest of the group exercised 92% of sessions.

Attrition

With a 2 x 3 repeated measures design, a medium effect size, and an alpha-level of .10, 11 subjects in each group were necessary for adequate statistical power. Though 21 subjects were measured during the pre-test sessions, only 15 (71%) completed the study. The attrition rate (29%) for this study was similar to many seen in the literature (Table 3). Reasons for attrition included: death (1 control subject), stroke (1 exercise subject), falls resulting in fractures (1 exercise, 1 control), and disinterest in continuing the program (1 exercise, 1 control).

Although subjects were initially evenly-distributed among the two facilities, the nursing home had a higher attrition rate than the assisted-care facility (respectively, 42.8% and 21.4%). The assisted-care facility was aesthetically much nicer than the nursing home, had a higher staff-to-resident ratio and a higher staff retention rate, and its residents generally came from a higher socioeconomic
status than those of the nursing home. These differences may have influenced the attrition of subjects.

Table 3

Attrition Rates in Studies of Nursing Home Exercise Programs with n<50

<table>
<thead>
<tr>
<th>Study</th>
<th>Original n</th>
<th># Drop-outs</th>
<th>Attrition Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiatarone, et al. (1990)</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fisher, et al. (1991)</td>
<td>18</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>McMurdo &amp; Rennie (1993)</td>
<td>49</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Naso, et al. (1990)</td>
<td>15</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Sauvage, et al. (1992)</td>
<td>12</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Thompson, et al. (1988)</td>
<td>35</td>
<td>13</td>
<td>37</td>
</tr>
</tbody>
</table>

Note. Full citations for each study are found in the References section.

Analysis of Data

A 2 x 3 (groups x time) repeated measures ANOVA was used to analyze the data. (See Appendix D for raw data.) A multivariate F-test showed a significant overall Group effect (F = 16.5, p < .0005) at a power of 1.0 and effect size of .90. Further univariate analysis indicated that two of the five variables contributed most to the overall effect: a) Eyes Open (EO), side-by-side stance (F = 7.75, p = .015), and b) the 6-meter Walk (F = 9.92, p = .008). These scores may be slightly inflated, however, because the exercise subjects all scored 30.0 seconds for the pre-test EO variable,
yielding a variance of 0. Thus, sphericity (an assumption of univariate ANOVA that correlations of variance between test sessions are not significantly different) could not be tested and might have been violated.

Referring to the group means (Table 4 and Figure 1) for the EO stance measure, it appeared that the exercise and control groups had significantly different scores at every testing session. The exercise group mean score was higher at each time than the control group mean. Therefore, the group effect for this measure could have been due to real group differences. The group means for the Walk measure were not significantly different at the pre-test, according to paired

Table 4

<table>
<thead>
<tr>
<th>Measure</th>
<th>Group</th>
<th>Mean &amp; SD (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre</td>
</tr>
<tr>
<td>Raise</td>
<td>Exercise</td>
<td>4.9 +/- 3.2</td>
</tr>
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<td></td>
<td>Control</td>
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</tr>
<tr>
<td>EO</td>
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<td>Control</td>
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<tr>
<td>EC</td>
<td>Exercise</td>
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<tr>
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<td></td>
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t-tests (Appendix E), but they were significantly different at both midpoint and post-tests (Table 4 and Figure 2). This would seem to indicate a Group x Time interaction; however, no such effect was significant using repeated measures ANOVA, so no conclusions can be made.

Note. A shorter time (seconds) for the Walk measure relates to better performance.
The overall Group x Time interaction \( (F = 1.03, p = .54) \) was not significant. There appeared to be a linear trend in the Chair Raise measure \( (F = 4.09, p = .06) \). However, with no statistically-determined Group x Time interaction, this linear trend cannot be verified (see Table 4 and Figure 3).

Figure 3

Chair Raise

Note. A shorter time (seconds) for the Chair Raise measure relates to better performance.

The overall Time effect also was not significant \( (F = 1.53, p = .36) \). There appeared to be a linear trend across groups for Time effect in both ADLs \( (F = 5.09, p = .04) \) and EC stance \( (F = 5.18, p = .04) \). Both exercise and control groups tended to decrease in ADLs over time and to increase in EC over time (see Figures 4 and 5). Again, these
univariate analyses cannot be deemed reliable, as there was no significant overall Time effect.

Figure 4

ADLs

![Graph showing ADLs over time for Exercise and Control groups.]

Figure 5

Eyes Closed Stance

![Graph showing mean performance over time for Exercise and Control groups.]

Paired t-tests were used to determine if the two groups were significantly different at the pre-test measures. No
initial differences were found, with p-values ranging from .18 to .63, so the repeated measures ANOVA results were considered most reliable. Appendix E lists mean differences between groups and p-values for each pre-test measure.

Power

The lack of significance in most measures may be partly due to low power. Table 5 shows significance and power levels of all multivariate analyses and of univariate analyses of the Group effect, which showed significance. Those tests with high power tended to indicate significance, while those with low power all showed no statistical

Table 5

<table>
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<tr>
<td>Walk</td>
<td>9.92</td>
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*Denotes significance with alpha = .10.*
significance. In this study, power was affected by low sample size and high variability of scores.
Chapter 5
Discussion

This chapter involves a discussion of the results and conclusions of this study. It begins with an explanation of the factors which may have affected the results of this study. The results will be discussed, followed by difficulties encountered, ideas for future research, and conclusions.

Factors that Impacted Results of the Study

Sample size

As discussed in Chapter 4, only 15 of the original 21 subjects completed the study. The factors leading to attrition in this study were seen in other studies and are common in the nursing home environment. Therefore, significant attrition of subjects is likely in any long-term study of this population. To combat this risk, subjects should be recruited in larger numbers (preferrably 20%-30% more than needed for statistical significance) and further in advance to allow time for more thorough recruiting. Due to time constraints of this study, control subjects were recruited only 1 week prior to, or during the first week of, program initiation. The low sample size might have affected the results, making it more difficult to identify changes due to the exercise intervention.
Power

The low sample size in this study affected statistical power. Power is the probability of finding a statistical difference when there is in fact a difference in the study sample; thus, it is a correct decision not to accept the null hypothesis ($H_0$). As seen in Table 5, those $F$-tests which had high power showed significance, while those with low power showed no significance of results.

Variability

Power is also affected by variability of results within a given measure; if variability is high, power tends to be low, and vice versa. The population studied exhibited high day-to-day variability in some measures, as well as variation throughout the day. This variation may be explained by effects of multiple medications, poor sleep patterns, physical fatigue, and illness, among other factors. Exercise and test times were standardized in this study, in an attempt to reduce within-day variation. Variability of subject performance was relatively high (Table 4, Means and Standard Deviations). Of particular note is the high variability in the EC measure (Figure 6). Upon visual inspection, there appeared to be a linear improvement in EC in the Exercise group mean scores, but the high standard deviations masked any possible change.
Results

Group effect

The first noted significant difference was an overall Group main effect. Further univariate analysis indicated that two measures, EO stance and the 6-meter Walk, contributed to the overall effect. Visual inspection of group means for the EO stance measure (Figure 1) indicated that the two groups had significantly different scores at all 3 times. There are two possible explanations for this: first, the two groups were truly different in these scores; and second, scorer bias contributed to the difference.

Figure 6

Eyes Closed Stance:

Means & Standard Deviations

![Graph showing mean performance (seconds) over time (weeks) for Exercise and Control groups. The graph displays a clear increase in performance for the Exercise group compared to the Control group.]
Although one cannot be certain which explanation or what combination of the two led to the difference, it is worth noting that the directions for the balance portion (EO and EC) of the assessment were imprecise and susceptible to observer variability (See discussion in Chapter 3). In addition, while the Exercise group scored higher on the Eyes Open stance measure at pre-test, the Control group scored higher on the Eyes Closed measure. This lends support to the theory that observer variability may have affected these results more than actual group differences. On the contrary, the Group effect for the Walk measure appeared, by visual inspection, to be an actual difference over time. It appeared that the two groups were not significantly different at the pre-test measures, but diverged significantly from that time. However, as mentioned in Chapter 4, there was no statistical significance shown in the Group x Time analysis, so no conclusions can be made.

**Group x Time interaction**

There was no overall Group x Time interaction as analyzed by multivariate statistics. The lack of significance may be due to low power, as the only significant univariate test was for the Chair Raise measure, which had a moderate power of .60, while all other measures had power ranging from .11 to .36. On the other hand, the significant univariate finding may have been inflated, as sphericity could not be tested. Visual observation of group means over
time for the Chair Raise measure seem to indicate a difference (Figure 3).

**Time effect**

There was no overall Time effect as analyzed by multivariate statistics. Visual inspection and univariate analysis indicated a linear effect in both ADLs and EC. ADLs of both groups decreased slightly and linearly over time, while EC stance of both groups increased slightly over time. The EC measure exhibited high standard deviations for both groups, such that there were no significant differences noted between groups, even though the means were quite different at the pre-test measure. As mentioned previously, this high variation in scores lowers power, making interpretation of results difficult. In addition, the lack of significance of an overall Time effect means that any significance in the univariate analyses cannot be verified.

**Other observable results**

The following results were deemed important, even though statistical analysis either was not conducted or showed no significance. First, the greatest gains in the Exercise group over the Control group were seen in the Chair Raise and Walk measures. This was important because the lower extremity exercises conducted in this study were designed to improve mobility. Specificity of training would uphold that the repeated rising from a chair and half-squats exercises improved subjects' performance in the Chair Raise measure,
and that toe raises, lunges, and forward and backward standing straight-leg raises improved subjects' performance in the Walk measure. In addition, a co-investigator found a significant improvement in the exercise group after the 5-month exercise period, over a 5-month control period immediately prior, in the measures of Chair Raise ($p < .05$), Walk ($p < .05$), and Eyes Closed stance ($p < .05$) (Protiva, Snow, DeVries, and Shaw, 1996).

Second, one exercise subject who was initially unable to rise from a chair without using her arms was able, at the post-test measure, to rise using only her legs. Her time for that measure improved by 2.7 seconds over the 5-month exercise period, from 6.5 to 3.8 seconds.

Third, it appeared, by visual inspection, that subject scores for the static balance measures (EO and EC) were unrelated to their scores for the mobility measures (Walk, Raise, and portions of the BI). This observation supports those by Lord, Caplan, & Ward (1993), who found that static balance measures in similar-aged subjects were unrelated to dynamic balance and mobility measures. In the current study, three subjects who used walkers and had lower scores for mobility measures also had typically high scores for static balance measures (See Raw Data, Appendix D).

**Difficulties**

Research with nursing home residents often poses difficulties encountered with few populations. Attrition rate and variability of scores were discussed earlier, so
they will not be specifically discussed here. Other difficulties in this research will be discussed.

When dealing with subjects who lived in nursing homes, it was ethically important to maintain their sense of autonomy as much as possible. In the nursing home, they had less control over their environment than they had previously as adults, and many felt the need to control "smaller" daily events. This need for autonomy made controlling experimental parameters and research conditions difficult. In this study, for example, random assignment to groups was not feasible. This was partially because of the small pool of available subjects. Potential subjects were ambulatory women who lived in local assisted-care facilities, who had no chronic illnesses which would confound results, and who were able to complete the exercise regimen. Random assignment also was not feasible because many eligible subjects did not want to spend prime time 3 days per week exercising. Many of these women agreed to the testing, however, so became control subjects. These same subjects would not agree to a group socialization period twice weekly, which was proposed to control for the group socialization experienced by the exercise subjects. This forced the investigator to spend time visiting each control subject individually, rather than as a group, which may have affected the groups differently.

Another difficulty involved autonomy, combined with dementia. Two exercise subjects had early stages of Alzheimer's disease, as stated by the nursing staff, and
often forgot that they had agreed to participate in the research program. Both were educated women and advocates of research, and they readily agreed to the program. However, they often were unable to be located during exercise time or refused to attend exercise class because they forgot that they had made the commitment. As a result, these two exercise subjects had the lowest attendance records, 55% and 74%, which may have affected their performance. Much time was spent reviewing the research program to these two women and encouraging them to participate, knowing that they could not be forced to do so if they chose otherwise.

Psychological factors, especially depression, can be a hindrance to participation with this population. A potential control subject who was chronically depressed agreed to initial testing, then lost interest quickly and refused further testing. One exercise subject was improving gradually between the first two test sessions until her closest friend in the home died. After that event, the subject became depressed, gradually coming less frequently to exercise class--finally coming only once in the last month--and complaining more frequently of pains and illnesses. Her post-test scores were significantly different than the other subjects' scores, so her data was dropped as an outlier.

Prolonged illness presented problems during this research. During midpoint testing, two control subjects were too ill to participate in testing. One had a persistent bed sore from sitting for extended periods, so she was
uncomfortable in any position but lying for four weeks. She had been advised by her nurse to avoid sitting and transferring as much as possible, which made testing impossible. The other subject was very uncomfortable for several weeks from an osteoporotic spine and, thus, refused testing.

Diet and medication changes may have influenced physical performance, though these were not examined in this study. Difficulties encountered in this study included low sample size, high variability of scores, attrition of subjects, inability to randomly assign subjects to groups, and dealing with Alzheimer's subjects, depression, and prolonged illness.

**Suggestions for Future Research**

1. A similar exercise program should be designed to examine the effects of progressive resistance exercise on this population for ADLs and stability, but which has a larger pool of subjects from which to choose. A larger sample size could compensate for any attrition of subjects. A large urban nursing home which could randomize assignment of exercise and control subjects (such as by floor or wing of the home) would be ideal. This would be similar to randomizing classrooms to separate groups, in that it would isolate groups enough to prevent exercise subjects from influencing control subjects regarding the research.

2. Control subjects should receive similar social treatment as exercise subjects. If a large enough pool of
subjects was available, those assigned as control subjects could be on a waiting list for the exercise program. In such a situation, these subjects may be more likely to participate in social activities two or three times weekly.

3. All women in this study were Caucasian, as was the case with most studies reviewed in Chapter 2. Similar studies involving different races should be implemented in order to further study the effects of genetics and physical activity level on osteoporosis and mobility in later life.

4. More exercise programs studying psychological hindrances and effects of exercise on the frail elderly population should be implemented. Those who agree to exercise may be different in levels of ambition, positive thinking, depression, and tolerance of pain, among other psychological measures, from those who refuse to exercise.

5. A similar exercise program with people who need more assistance in ADLs, but who could still complete the exercise regimen, is suggested for further research. Many of the subjects in this study were independent in ADLs or required very little assistance; thus, there was little room for improvement in this measure.

**Conclusions**

Independence in activities of daily living is important for autonomy and sense of well-being of institutionalized older adults. If an exercise program would improve the
elderly person's balance and strength, it may allow him or her to be more independent in ADLs. This study was unable to identify consistent statistically significant differences between groups after the 5-month exercise program. This may have been related to low sample size, subject variability, or possibly an ineffective treatment program. Following some of the suggestions for future research outlined above, a researcher would have a more solid research design and better ability to detect true differences between groups over time. Many difficulties arise when researching with this population, some of which can be controlled. With these in mind, careful design and selection of locations to administer research could be improved over the described study. This study failed to determine that a 5-month resistance exercise program would improve ADLs and functional mobility. However, limitations in sampling and other factors may have contributed to the lack of statistical significance. Further research is needed to address these unanswered questions.
References


APPENDICES
Appendix A
The Barthel Index of ADL

Feeding
0 = Unable.
1 = Needs help cutting, spreading butter, etc.
2 = Independent (When food is provided within reach, the individual can put on any necessary assistive device, cut food, use seasonings, and spread butter within a reasonable time.)

Bed Transfer
0 = Unable--no sitting balance.
1 = Able to sit up independently, but needs to be lifted out of bed, or transfers with a great deal of help.
2 = Minimal help is needed, including verbal prompts or supervision in any part of the activity.
3 = Independent.

Grooming
0 = Needs assistance with personal care, including washing hands and face, combing hair, brushing teeth, fitting false teeth, applying makeup, and shaving. Implements can be provided by helper.
1 = Independent. (Implements may be provided.)

Toilet use
0 = Dependent.
1 = Needs some help, but can do some parts alone.
2 = Independent. (Able to get on and off toilet, undress sufficiently, and use toilet paper without help.)

Bathing
0 = Dependent in any aspect of the process, including supervision.
1 = Independent, using choice of bath tub, shower, or complete sponge bath. Able to get into and out of tub/shower, and wash self unsupervised.

Mobility
0 = Immobile.
1 = Able to propel wheelchair independently, including corners and doors, for at least 50 yards.
2 = Walks with help (including use of a rolling walker) or supervision for at least 50 yards.
3 = Independent in walking at least 50 yards. May wear braces or prostheses and use crutches or cane but not a walker.
Stairs
0 = Unable to ascend or descend stairs.
1 = Needs help or supervision in any aspect of ascending or descending stairs.
2 = Able to go up and down a normal flight of stairs safely without help or supervision. May (and should) use handrails, cane, or crutches when needed. Must be able to carry any assistive device normally used.

Dressing
0 = Dependent in more than 50% of work for dressing.
1 = Needs help in putting on and removing or fastening any clothing (not including women's brassieres or girdles). Must do at least half of work in a reasonable amount of time.
2 = Independent in putting on, removing, and fastening (zippers, buttons, shoe laces) clothing, which may be adapted to achieve independence.

Bowel continence
0 = Incontinent.
1 = Needs help in using suppository, taking enema, or handling colostomy bag, or has occasional accidents (once/week at most).
2 = Continent, or can independently handle colostomy bag. Can use suppository or take enema when necessary.

Bladder continence
0 = Incontinent.
1 = Has occasional accident (less than once/day) or needs help with catheter.
2 = Continent day and night, or can manage catheter and leg bag independently.
Appendix B
Consent Form

The Effects of Resistance Exercise on Fracture Risk Factors in Elderly Women.

Investigators: Christine Snow, Ph.D., Associate Professor, Department of Exercise and Sport Science, 737-6788. Karen Protiva, MS, Doctoral student, EXSS Department, 737-3343. Christine DeVries, Master's student, EXSS Department, 737-5927.

Purpose: The purpose of this investigation is to examine the factors proposed to alter postural stability and bone mineral density in elderly women living with assisted care over a 10-month period. Subjects will be asked to visit the laboratories at OSU Women's building for repeated tests and, if necessary, will be transported via OSU vans.

I have received an oral explanation of the study procedures and understand they entail:

1. Bone mass
   Evaluation of bone mineral density of my spine, hip, and whole body will be measured using bone densitometry. Prior to the bone density evaluation, I understand that I will be asked to complete a health and activity questionnaire. I have been informed that the scan requires that I lie quietly on a table for eight minutes for spine and hip evaluation and 15 minutes for whole body evaluation. The scan begins by having me lie on my back on the bed of the bone mineral density machine. The trained operator will position me according to the areas of interest. It is required that I lie completely still during the testing procedure to establish an accurate measurement of bone mineral density. To measure the spine and hip, positioning devices from the manufacturer will be used to aid in locating the specific area of interest. I further understand that I will experience no discomfort from the procedures.

2. Tests of strength
   Strength (peak torque) of the hip, calf, and quadriceps will be assessed using a strength measuring instrument located at OSU Women's Building. The operator will explain the procedure of the tests both verbally and by illustration. I will be positioned on the machine correctly, according to the muscle to be measured, and then asked to perform 3 to 5 warm-up trials. Following the warm-up, I will be asked to perform 5 tests, each test will be a maximal effort. The maximal trials will be separated by one minute rest intervals. Hip muscle strength will be measured on my right
I will be in a supported standing position with a pad placed comfortably on mid-thigh. Calf muscle strength will be measured on my left leg. I will sit in an upright position with the leg to be tested supported in a positioning device. Quadriceps muscle strength will be measured on my left leg. I will sit in an upright position with the leg to be tested positioned at 90 degrees. A pad will be positioned comfortably on my shin. This test requires that I apply force to a pad which will ultimately measure strength.

3. **Functional tests of postural stability**
   The investigator will show me the following tests which I will perform to the best of my ability: 1) timed rising and returning, without using arms or walker/cane, from a hard, straight-backed chair; 2) standing with my feet side-by-side with my eyes open and with my eyes closed until my body sways or my feet lift or shuffle; 3) and walking as fast as possible along a path for 236 inches. I will perform each task twice, the best score will be recorded.

4. **Assessment of activities of daily living**
   An investigator will assess me in the following daily activities which I will perform as usual: walking, going up and down stairs, dressing, grooming, getting into and out of bed, and eating. Daily activities of bathing, toileting, and bladder and bowel control will be assessed by my primary caregiver who will answer questions from a standardized test.

5. **Exercise program:**
   I will attend an exercise session within my residence three times per week for 20 weeks.
   Leg exercises will include: standing on one leg, while raising my other leg to the front and to the back; standing with feet shoulder-width apart and raising up on my toes and rocking back on my heels; standing with feet shoulder-width apart and bending my knees no more than 90 degrees; lunging forward; sitting in a chair and raising to the standing position and returning to a seated position without using my hands, if possible. All standing exercises will be done with hand supports available. At the beginning of the exercise session, I will wear a vest with no additional weights. As the weeks progress and my strength increases, I will add weight to the vest in 0.5-pound increments according to the percentage of body weight as indicated in the table below.
   Abdominal exercises will include sitting in a chair and raising my knees toward my chest.
   Arm exercises will be done while seated, using a small hand weight to raise each arm straight to the side; curl the arm upward, bending at the elbow; straighten the arm at the elbow, pushing it downward and backward; twisting the weight in my two hands, arms held out straight in front of my body; and grasping the weight in both hands with the arms straight out in front, and pulling the weight toward the chest, then
pushing it out straight in front again. The weight will be increased in 0.25-pound increments every two weeks.

Each exercise will be demonstrated by the instructor. I understand that others will be participating and that one or more instructors will be at each session to assist me with these exercises. The leg exercise progression will be as follows:

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<td>19-20</td>
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<td>2</td>
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6. **Risks**

Evaluation of bone mineral density of my spine, hip, and whole body uses very low levels of radiation. It has been explained that this radiation dose is considered safe to administer on several occasions to women in my age group. No injections are given and there are no known hazards from radiation at such low levels. There is less than one chance in a million of causing malignancy. There is a chance that I may feel muscle soreness following the strength testing, but I realize this is a short term effect and the soreness will gradually diminish with time. Since I will be warming up prior to maximal efforts on the strength tests, my risks for injury are considerably less. I am also aware that there is a remote risk of injury associated with the postural stability tests primarily due to falls. Furthermore, trained personnel will be administering the test and monitoring for signs of exercise intolerance. If I experience pain, I will discontinue the test. I understand that by participating in the exercise program, I may injure myself from falling. The chance of falls is reduced considerably since trained personnel will be present at all exercise sessions.

7. **Benefits**

I will benefit from this study by receiving information on my bone mineral density, strength, and balance. This information may be useful in making decisions concerning wellness issues. I will also benefit by participating, and will aid in the understanding of the relationship that specific upper and lower extremity resistance exercises has on bone mineral density, balance, and activities of daily living.

8. **Confidentiality**

Confidentiality will be maintained by assigning me a code number to be used when recording all data. Information
concerning my data will be available to the researchers performing this study. In the case of presentation or publication of this study, my name will not be used.

9. **Agreement**

I understand that the University does not provide a research subject with compensation or medical treatment in the event the subject is injured as a result of participation in the research project. I am aware, that if I approve, my personal physician may be contacted prior to my being accepted into the study and if I object, my personal physician will not be contacted.

____ I give approval for my physician to be contacted and have listed his/her name and phone number.

_________________________  ______________________
physician’s name                phone number

____ I do not give approval for my physician to be contacted.

I have been completely informed and understand the nature and purpose of the research project. The researchers have offered to answer any further questions that I may have. I understand that my participation in this study is voluntary and I may withdraw from this study without prejudice or loss of benefits to which my participation entitles me.

I have read the foregoing and agree to participate in this study.

_________________________  ______________________
subject’s signature                date

_________________________
subject’s address

_________________________  ______________________
investigator’s signature                date

_________________________  ______________________
physician’s signature                date
TITLE: The effects of lower extremity resistance exercise on fracture risk factors in semi-vigorous women

PRINCIPAL INVESTIGATOR: Christine Snow-Harter

STUDENT: Karen Protiva and Christine DeVries

COMMITTEE DECISION: Approved

COMMENTS:

The informed consent form obtained from each subject should be retained in the program/project's files for three years beyond the end date of the project.

Human Subjects Committee Chair: [Signature] Date: February 9, 1995

Warren N. Suzuki (Education, 7-6393 or suzukiw@ccmail.orst.edu)
## Appendix D

### Raw Data

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Appendix E

Mean Differences Between Groups for Each Pre-test Measure

Paired t-tests were used to determine if there was a significant difference between the Exercise and Control groups at the pre-test measure. The results found no significance, as follows:

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