Evaluating the effectiveness of a home-based multifactorial fall prevention program for community-dwelling older adults

by Shawna Marie Yates

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Health and Human Development
Montana State University

Abstract:
Falls are a serious public health concern for older adults, with nearly 30 percent of adults over the age of 65 falling each year. Previous research has shown falls to be related to the number of fall-related risk factors. A number of investigations have been conducted to reduce the risk of falls in seniors. However, no published studies have investigated a multifactorial fall prevention program, targeting enhanced physical activity, proper nutrition, and environmental hazards education. Therefore, the purpose of this study was to determine if a home-based multifactor fall prevention program reduces select fall-related risks in a sample of rural dwelling seniors in southwest Montana. The researcher hypothesized that an intervention program targeting enhanced physical activity, proper nutrition, and environmental hazard education would positively change select fall-related risk factors: balance, upper body flexibility, ankle flexibility, bicep endurance, lower extremity power, mobility, environmental hazards, depression, falls efficacy, nutritious behavior, and nutritious locus of control.

A randomized, controlled 10 week intervention study was conducted on 37 subjects. Paired t-tests were done to determine mean change scores within groups for each dependent variable. Unpaired t-tests were run to determine mean difference between groups. Last, simple regression models were used to determine if group designation predicted change in outcome variables.

The analysis revealed statistically significant changes for the intervention group on balance, arm strength, leg strength, reduction of environmental hazards, and reducing the total number of fall-related risk factors in each of the statistical tests: t-test within group, t-test between group, and simple regression. The intervention was found to be predictive of changes in balance (R2=35.4%), bicep endurance (R2=29.6%), mobility (R2=9.1%), lower extremity power (R2=22.9%), nutritious behavior (R2=I4.0%), and number of environmental hazards (R2=I9.6%). Most importantly, the intervention explained almost half of the variance in the number of total fall-related risks (R2=47.4%).

In conclusion, the fall prevention intervention consisting of exercise programming, nutrition counseling, and environmental hazards education reduced six of the eleven fall-related risk factors evaluated.

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date January 11, 1999

VITA

Shawna Marie Yates, daughter of Michael and Terrie Button, was born in Butte, Montana, on November 16, 1973. She attended public schools all over Montana, and graduated from Plains High School, in Plains, MT in 1992.

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ABSTRACT

Falls are a serious public health concern for older adults, with nearly 30 percent of adults over the age of 65 falling each year. Previous research has shown falls to be related to the number of fall-related risk factors. A number of investigations have been conducted to reduce the risk of falls in seniors. However, no published studies have investigated a multifactorial fall prevention program, targeting enhanced physical activity, proper nutrition, and environmental hazards education. Therefore, the purpose of this study was to determine if a home-based multifactor fall prevention program reduces select fall-related risks in a sample of rural dwelling seniors in southwest Montana. The researcher hypothesized that an intervention program targeting enhanced physical activity, proper nutrition, and environmental hazard education would positively change select fall-related risk factors: balance, upper body flexibility, ankle flexibility, bicep endurance, lower extremity power, mobility, environmental hazards, depression, falls efficacy, nutritious behavior, and nutritious locus of control.

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In conclusion, the fall prevention intervention consisting of exercise programming, nutrition counseling, and environmental hazards education reduced six of the eleven fall-related risk factors evaluated.

CHAPTER 1

INTRODUCTION

Humans are unique in their bipedal strategy for locomotion. Our complex postural control system helps us to walk upright and maintain balance in many challenging situations. However, problems can and do occur with this system. Our balance and gait can become disrupted. As one ages, the complex postural control system is often compromised, making it more and more difficult to avoid falls. Approximately 30 percent of the non-institutionalized people over the age of 65 fall each year (Sattin, Lambert Huber, & DeVito, 1990; Tinetti, Speechley, & Ginter, 1988). One-third of those who fall suffer moderate to severe injuries (Alexander, Rivara, & Wolf, 1992). Nearly 200,000 Americans fracture their hips each year, usually as a result of a fall (Wylie, 1977). The National Safety Council (1993) has cited death due to unintentional injury, such as falls, as the sixth leading cause of mortality among those 65 and older. Consequently, falls have serious repercussions for older adults due to their frequency and the morbidity associated with them.

Medical attention is often needed for fall-related injuries. A study done by Kiel, O'Sullivan, Teno, & Mor (1991) found a greater use of the health care system by those older adults who had fallen. Falls impinge on the economics of the health care system and the victims of falls. Urton (1991) reported that between $75 and $100 billion are associated directly or indirectly with the cost of falls each year. Other costs include physical suffering, mental anguish, days in the hospital, transfers to extended care facilities and loss of an independent lifestyle.

Once an older person falls, a downward spiral often begins. They may live in constant fear, become less active, less independent, and less confident. One of the most common fears among the elderly is the "fear of falling" (Redford, 1991). Fear may result in tremendous impact on quality of life and physical decline (Walker & Howland, 1991).

This health concern is continually growing because America's population is aging. Due to the baby-boom during the middle third of this century, the age group over 65 is the fastest growing segment of society. Today there are 31 million people over the age of 65, comprising 12% of the U.S. population. By the year 2040, there will be a projected 66.6 million people over the age of 65 in the United States (Gelman, et al., 1985).

Significance of the Study

There is broad public consensus about the importance and need for fall prevention programming. The United States Public Health Service (1990) has joined in the campaign to prevent seniors from falling. In the Healthy People 2000: National Health Promotion and Disease Prevention Objectives, the policy makers have outlined a plan to reduce falls by the year 2000 (Kennedy & Coppard, 1987). Some of these objectives includes:

- reduce hospitalization for hip fractures in women over 85 years by 20%
- reduce mortality rate from falls in the 65-84 age group from 18 to 14.4 per 100,000

- reduce mortality rate from falls in the 85+ age group from 131 to 105 per 100,000

In order to reduce the consequences of falls for both the individual and society, it is imperative that preventive steps be taken to reduce the risk of falling for older adults. Studies have shown that incidence of falls is related to the number of fall-related risk factors (Cutson, 1994; Tinetti, et al., 1988). Reducing just one fall-related risk factor can have a great impact on the frequency and morbidity of falls. Reducing the incidence of falls among older adults will help reduce high health care costs for the individuals, their families, and the United States taxpayers. Most importantly, by reducing the falls suffered by older adults, their quality of life can be improved. They can become empowered to continue living an active and independent lifestyle.

The following fall prevention program is designed to inform and empower older adults about fall-related risk factors. It provides seniors with tools to begin an in-home exercise program, assess their nutritional health, and make changes to environmental hazards. The program is designed to motivate and educate the older adult about their role in fall prevention; and to reduce their overall risk of falling.

Statement of the Problem

The purpose of this study is to determine if a home-based multifactor fall prevention program reduces select fall-related risks in a sample of older adults from rural Montana communities.

Research Hypothesis

A home-based multifactor fall prevention program, targeting enhanced physical activity, proper nutrition, and environmental hazards education will positively change select fall-related risk factors in a sample of older adults.

Definition of Terms

For purposes of this study the following definitions will be observed:

Fall	will be defined as "an event which results in a person coming to rest inadvertently on the ground or other lower level and other than as a consequence of the following: sustaining a violent blow; loss of consciousness; sudden onset of paralysis, as in a stroke; or an epileptic seizure" (Kennedy & Coppard, 1987).
Older adults	will be defined as those persons over the age of sixty-five.
Multifactor	will be defined as targeting more than two fall-related risk factors. Multiple risk factors will be observed.
Community-dwelling	will be defined as those persons independently living in their own homes or apartments, but not those in nursing or assisted-living facilities.
Rural	The Office of Management and Budget definition includes any county with less than 100,000 people and no cities with more than 50,000 people (Office of Management and Budget, 1983). Montana has only two counties that qualify as urban (Metropolitan Statistical Areas): Cascade and Yellowstone. The remaining 54 counties are considered to have rural populations.

Limitations

1.) The study was limited by the self-reported nature of the data. This posits a limitation in that there can be under-reporting and over-reporting of health characteristics and falls.

2.) Results of this study are only generalizable to populations similar to Gallatin County, Montana.

3.) Recruiting subjects was difficult, thus the sample size (N = 37) was small.

4.) The researcher, who conducted all aspects of the study, may have introduced bias through diverse interactions with the subjects.

Delimitations

1.) Data was limited to the survey questions and statements used in the investigation (See Appendix E).

2.) Physical measures were limited to the fitness tests for upper body bicep endurance, shoulder and ankle flexibility, gait speed, balance, and lower body power.

3.) Psychometric measures were limited to a depression scale, a falls efficacy scale, locus of control for nutrition, and nutritious behavior scale.

4.) Information on background characteristics was limited to age, gender, marital status, living arrangement and education.

5.) Information on self-rated health characteristics was limited to vision, hearing, alcohol use, tobacco use, sedative use, high blood pressure, hospitalization in the last year, physical activity, foot problems, and the average number of prescription medications.

Assumptions

The investigator assumes the subjects were truthful and accurate on all information reported throughout the study. The number of fall-related risk factors were presumed to increase a persons chances of falling, therefore a decrease in the number of risk-factors will decrease a person's risk of falling.

CHAPTER 2

REVIEW OF LITERATURE

For older people any loss of functional capacity can increase the risk of losing independence. This risk, coupled with the tendency to become more sedentary with age, leads to a population with much to lose- and much to gain.
(The United States Public Health Service, 1992)

Falls for older adults can be caused by any number of fall-related risk factors. Many of the risk factors are considered as a natural part of aging, however, many adults are learning that physical activity over the length of the life-span can prevent many of the risk factors associated with falling. This chapter will review; 1) conceptual models surrounding falls and fall prevention, 2) select fall-related risk factors, and 3) previous fall reduction research conducted on senior populations.

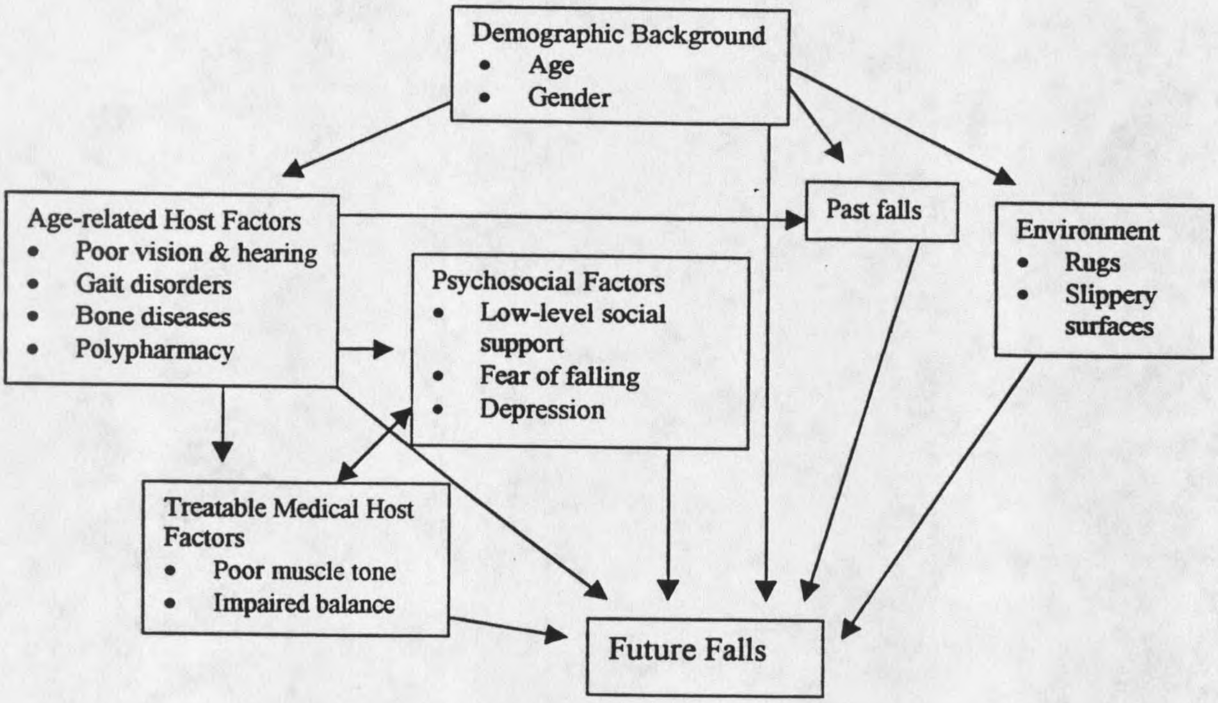
Conceptual Models

For the past 40 years, researchers and physicians have been struggling to find an efficacious fall prevention model for the elderly. To this end, a number of conceptual models have been developed. The first is called the single cause model. The single cause model was developed on the intuition that a person's fall is based upon a single cause, such as a dangerously placed throw rug. However, the risk is typically multi-dimensional and may include problems with vision, strength, and balance; but the only cited cause for the fall was the rug. Therefore, Buchner (1997b) concluded that the single cause model did not adequately address the complexities associated with a comprehensive fall prevention program.

A more appropriate model for understanding falls is called the host-agent-environmental model, which is based upon injury control research (Fabrega, 1975). Hogue (1984) described this model in the institutional setting and called it the ecological model. He emphasized the interaction between the older person and the environment is divided into two phases. The first phase is the pre-injury phase and includes the risk factors associated with a fall. The second phase is the injury phase and includes risk factors for an injury. Conceptually, the phases provide a two step pathway that requires a host and environmental risk factor for a fall (poor balance & slippery surface) and a second set of risk factors for injury (weak bones & falling on a hard surface). The ecological model also takes into account that older persons are influenced by experiences of other older adults and attitudes expressed by health care professionals. For example, the knowledge of someone falling will dictate how one copes with the future possibility of falling. Based upon the ecological model a fall prevention plan must incorporate current beliefs about falls and treatment of an array of host-environment risk factors.

Because falls are associated with a heterogeneous group of events with complex causal pathways, investigators have also viewed fall prevention from a social epidemiological model (Cwikel & Fried, 1992). This model (Figure 1) incorporates many causal pathways that are associated with falls. For example, the model shows that past falls alone can be an indication of future falls. Also, it incorporates the notion that age, gender, physical decline, depression and environment may all be related to future falls. Consequently, this model seems to be the most comprehensive approach to date and a logical framework to use in the development of fall prevention programming.

Figure 1: Schematic of social epidemiological model.

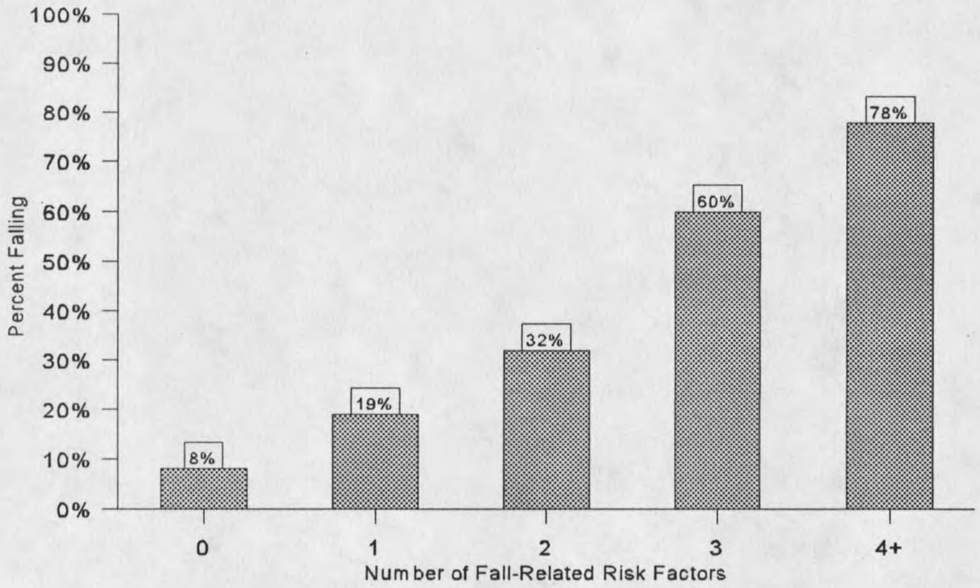


<u>Review of Fall-Related Risk Factors</u>

A number of studies have been conducted to identify fall-related risk factors (Clark, Jackson, & Cohen, 1996; Cutson, 1994; Dunne, Bergman, Rogers, Inglin, & Rivara, 1993; Hindmarsh & Estes, 1989; Nevitt, Cummings, & Hudes, 1991; Sudarsky, 1990; Tinetti, et al., 1988; and Tinetti, McAvay, & Claus,1996). Tinetti et al. (1988)

found the risk of falling increased linearly with the number of risk factors, from 8 percent with no risk factors to 78 percent with four or more risk factors (Figure 2). In order to study the risk factors associated with falling, the researchers conducted a one-year prospective study using 336 persons 75 years and older who were living in the community. The risk factors studied included sedative use, cognitive impairment, lower-extremity disability, palmomental reflex, foot problems, and balance-and-gait abnormalities. It was concluded that a simple clinical assessment can identify those who are at a greater risk of falling and interventions targeting these risk factors can help reduce a person's risk of falling.

Figure 2: Occurrence of Falls According to the Number of Fall-Related Risk Factors



Based upon the results of a variety of studies, a number of modifiable risk factors have been identified (Figure 3). Because these fall-related factors are the areas that are typically addressed in fall prevention programming, a review of each factor is provided.

Figure 3: Fall-related Risk Factors with Select Examples.

- Lack of Physical Activity
  - Impaired balance
  - Muscle weakness
  - Reduced mobility
  - Reduced flexibility
- Environmental Hazards
  - Improper footwear
- Impaired vision and hearing
- Polypharmacy
  - Psychoactive medications
- Orthostatic Hypotension
- Fear of Falling
- Depression
- Lack of Social Support

Lack of Physical Activity

Lack of physical activity creates a number of added difficulties for an aging person. For example, sedentary lifestyles can result in poor muscle strength, decreased bone mass, gait/balance disorders, and reduced flexibility (Sudarsky, 1990). All of these factors increase one's risk of falling, but can be modified with a regular exercise program (Campbell, Borrie, & Spears, 1989).

Exercise is considered the most effective behavioral and physical intervention plan for falls (Crilly, Williams, & Trenholm, 1989). Exercise programs that consist of strength training, balance activities, and flexibility development can quickly improve physical health. Weight-bearing activities have dramatic effects on muscle tone and strength even in person's over the age of 65 (Fiatarone, Marks, Ryan, Meredith, Lipsitz, & Evans, 1990). Furthermore, exercise can improve an older person's body mechanics, which will help in making adjustments and enabling seniors to more effectively address environmental hazards. In short, exercise has been shown to be effective at reducing a variety of fall-related risk factors.

Environmental Hazards

Environmental hazards have been implicated in at least a third of the falls among older adults (AARP, 1993). For example, an older person may be sitting in an unstable chair, which is a common environmental hazard for the elderly. Consequently, whenever he/she tries to rise from the chair he/she is at risk for falling, because the chair may collapse or move just enough for the person to lose balance and fall. The ubiquitous problem of environmental hazards is significant because these hazards are found in every home. Fortunately, these factors are the easiest to modify (Cutson, 1994). They can be as apparent as a loose throw rug or as subtle as the height of a toilet seat. If one is made aware of the enormous risks within the home, steps can be taken to prevent falls from environmental hazards.

An important environmental hazard that needs to be considered is the footwear of most older adults. Inappropriate footwear has been cited as a contributory factor in home falls (Tinetti, Speechley, & Ginter, 1988). There is a complex interplay between footwear, walking, and balance. Shoes with slick surfaces, high heels, or thick soles can cause problems with proprioception in the foot and stability (AARP, 1990). Therefore, older adults should be encouraged to wear sturdy shoes with laces and a non-skid sole (Dunne, et al., 1993).

Impaired Vision and Hearing

Sensory changes in vision and auditory abilities play a risk in falls. Thirty percent of older adults have significant hearing loss (Gray-Vickery, 1984). Hearing loss can place people at risk when out in public and within the home. For example, they may not hear the smoke detector sounding due to a fire. No warning will make it difficult for an older person to get to safety before the fire becomes life-threatening. Many instances, such as the smoke detector example, require quick reactions and may cause an older person to be frightened and hurried, which may result in a fall. It is recommended that older persons have their hearing checked yearly and wear hearing aids if their hearing is poor.

The association between vision and fall risk has been widely reported (Cohn & Lashley, 1985; Lord, Clark, & Webster, 1991; Tinetti, Williams, & Mayewski, 1986b). Impaired vision can disrupt one's depth perception and visual field (Clark, Jackson, & Cohen, 1996). Both may aid in slowing down a person's reaction time and judgement of environmental hazards (Kane, Ouslander, & Abrass, 1984). Moreover, this is important because, with aging, older persons increasingly use visual information compared with their use of other sensory inputs for controlling stability (Straube, Botzel, Hawken, Paulus, & Brandt, 1988). It is recommended that older adults have their vision screened yearly and use glasses with the correct prescription. Older adults may also use walking sticks and reflective tape on stairs to help with their environment.

Psychoactive Medications

The use of psychoactive medication also puts an older person at risk for falling. Psychoactive medications are sedatives, antidepressants, hypnotics and antipsychotics. Seventy-five percent of women over the age of 65 are taking at least one medication that fits in this category (AARP, 1993). Medications such as long-acting benzodiazepines and neuroleptics have been associated with increased hip fractures (Ray, Griffin, & Downey, 1989). These drugs can reduce mental alertness, worsen gait, and decrease systolic blood pressure (AARP, 1993). Seniors can be instructed to talk with their physician about the dangerous side-effects associated with these drugs and should reveal all medications (prescription and over-the-counter) they are currently using. Clear communication is important because many medications when taken together can have detrimental side effects, which are often associated with falling.

Orthostatic Hypotension

Orthostatic hypotension is one of the many physical disorders associated with falling. Orthostatic hypotension can be defined as a fall in blood pressure occurring upon standing. Common outcomes related to the blood pressure decrease include dizziness, blurred vision, and faintness. This condition is typically associated with malnutrition, certain medications (antihypertensives, neuroleptics and antiparkinsonian agents), or having poor vascular tone (Chipman, 1981; Gray, 1997). Older adults should be informed about the possible side-effects of the medications they are taking and be encouraged to discuss this with their physicians. Focus on adequate nutrition can also be an important intervention for seniors. For example, re-hydrating can help the vertigo associated with orthostatic hypotension. Finally, regular exercise can enhance vascular tone. Typically, these types of interventions can be used to effectively address the senior's problems with orthostatic hypotension.

Fear of Falling

Up to 50 percent of those who have fallen admit to avoiding many activities for fear they will fall and injure themselves (Tideiksaar, 1996; Tinetti, Mendes de leon, Doucette, & Baker, 1994a). Fear of falling can be viewed as a psychosocial risk factor of falls, and as a psychosocial outcome or consequence. Once older adults become fearful of falling, they may limit their mobility and restrict their activities. This behavior isolates older adults and reduces their independence. The fear of falling may also be associated with other fall-related risks. For example, once a person becomes fearful of falling and limits their activities, they are more likely to decrease physical activity and become weak (Arfken, Lach, Birge, & Miller, 1994). Exercise and modifying the home environment are possible interventions for seniors who are fearful of falling. Exercise can help seniors become stronger and more mobile, which will improve their confidence in performing the basic activities of daily living. Improving the safety of the home environment can also help seniors to feel more confident when maneuvering around their homes. Tinetti, et al. (1994a) found direct association between improved confidence and a decreased fear of falling.

Depression

According to Prudham and Evans (1981) falling is associated with depression. Clinical depression is a multifaceted disorder, characterized by affective distress, behavioral difficulties, and cognitive complaints (Teri, 1997). Depression is similar to fear of falling in that it may be a psychosocial risk factor of falls, and a psychosocial outcome or consequence. Among older adults depression may be an early sign of physical disease, a result of medication side-effects, lack of social network and/or any number of other causes. In relation to falls, depression must first and foremost be diagnosed by a trained health professional. Exercise has been shown to have a positive effect on depression by releasing endorphins that help one to feel better. Also positive social support can help people feel less lonely and blue. Older adults may begin an exercise program and increase social interaction to initiate treatment of depressive symptoms.

History of Fall Prevention

Seven intervention strategies for reducing falls among community-dwelling older adults have been reviewed: Urton (1991); Reinsch, MacRae, Lachenbruch, & Tobis, (1992); Tinetti, et al. (1994b); Cutson (1994); Lord, Ward, Williams, & Strudwick, (1995); Ryan & Spellbring (1996), and Buchner, et al., (1997a). The studies will be reviewed in relation to the conceptual framework explained earlier.

Single Cause Model

Urton (1991) developed a community-based home inspection program to reduce the prevalence rate of injuries due to falls by eliminating environmental hazards. The program involved an inspection team to identify hazards and college students and other community volunteers to rectify the hazards with donations that were given by area merchants. Urton proposed this program as a public health approach to reducing falls. It is based upon the single cause model because it targets only environmental hazards. This proposed intervention was not implemented and therefore only provides an example of a possible strategy for fall prevention programming based upon the single cause model.

Host-Agent-Environmental Model

Cutson (1994) recommended that education of fall-related risk factors and environmental manipulations may be the only interventions necessary for fall prevention. This proposal suggests an in-home evaluation to be done by a physician or a physical therapist. The evaluation includes a history of falls, physical exam, review of medications, and functional testing. Once fall-related risks have been identified, the researcher suggested interventions to help maintain a person's functional abilities. For example, if an older adult is having difficulty rising from a chair, the physician or therapist would suggest physical therapy, pain control, or assistive devices (Cutson, 1994). Cutson's proposal is helpful in identifying fall-related risk factors, but does not offer a comprehensive approach to risk reduction programming.

Social Epidemiological Model

The remaining four intervention studies target a wide variety of the fall-related risk factors. They coincide with the idea that falls occur because of a complex causal pathway.

In a pilot study conducted by Ryan and Spellbring (1996), an education intervention on fall-related risk factors was conducted. The incidence of falls and number of fall-related risk factor changes were measured. Forty-five women from two (one urban, one rural) senior meal sites were recruited. Subjects were randomized to three groups: one group received fall prevention education, one group received individual fall prevention education by a nurse, and a control group received health promotion presentations. The fall prevention interventions and the health promotion presentations consisted of three one-hour sessions.

Outcome measures included the number of fall-related risk factor changes, the type of fall prevention changes, and the number of falls. The greatest number of fall prevention changes was seen in the fall prevention group format. Among the women receiving the fall prevention intervention seventy-three percent made at least one fall prevention change in either their personal behavior or living environment. The most common change (61%) was personal/no cost changes, such as avoiding the use of bath oils, avoid walking in stocking feet, or increasing their physical activity. The control group experienced more falls and fall-related injuries than either of the two intervention groups. However, it is difficult to say if fall prevention education programming reduces the frequency of falls because of the small sample size. The results of this study suggest fall prevention programming targeting education does reduce the number of fall-related risk factors in a sample of older women.

Reinsch et al. (1992) studied the effectiveness of exercise and cognitive-behavioral programs in reducing falls and injuries among 230 older adults over a one-year period.

The subjects were recruited from 16 senior centers. The centers were randomly assigned to one of four treatment groups (exercise, cognitive-behavioral, exercise-cognitive, and discussion control). The low-intensity exercise program was designed to improve balance and strength. The class met for one hour, three days a week. The cognitive-behavioral intervention used hour long classes on a weekly basis to address fall-related health and safety issues. The exercise-cognitive class followed the cognitive-behavioral protocol one day per week and the exercise protocol two days per week. The discussion control group met once a week and reviewed health topics not specifically related to falls.

Outcome measures included monitoring falls, injuries, perceived health, fear of falling, lower extremity muscular strength, and balance. Results revealed that the interventions were not successful in achieving a reduction in falls by improving lower extremity muscular strength and balance, or by improving awareness of environmental hazards and medically related risk factors. This study found low-intensity exercise and cognitive education of fall-related risk factors as ineffective interventions for fall prevention programming.

Similarly, Lord et al. (1995) conducted a randomized, controlled trial of exercise programming in a sample of 200 older women who were recruited from the community. The researchers hypothesized exercise to have beneficial effects on muscular strength, neuromuscular control, reaction time, body sway, and reducing fall frequency. The subjects participated in exercise classes, through an existing community-based program. The exercise program focused on conditioning and stretching. Hourly exercise sessions were offered two times a week for 10 to12 week terms throughout a one year period.

The findings of this controlled trial revealed significant improvement in measures of lower limb strength, reaction time, neuromuscular control, and three of the four body sway measures. There was no significant difference in the proportion of fallers between exercise and control groups. However, fall frequency was related to exercise adherence, with those who attended seventy-five percent or more of the exercise classes had the lowest fall rate. Implications reveal exercise programming as an effective tool for reducing many fall-related risk factors among older adults.

A more recent study conducted by Buchner et al. (1997a) looked at an intervention of strength and endurance training to modify risk factors for falls. The study was a randomized, controlled trial of 105 older adults selected from a health maintenance organization. The subjects were randomized into one of three exercise groups or a control group. The groups included 1) the 6-month endurance training group (ET), which involved 30-35 minutes of aerobic activity three times per week, 2) the 6-month strength training group (ST), which involved 2 sets of 10 repetitions on 10 weight machines three times per week, 3) the 6-month strength training and endurance training group (ET+ST), which involved 20 minutes of endurance training and one set of the 10 strength training exercises three times per week, and 4) a control group. The classes ran for six months.

Outcome measures included strength, aerobic capacity, balance, gait, self-reported falls, and physical health status. Findings showed no effect of exercise on gait, balance, or physical health status for all three of the intervention groups. Strength improved for the ST and the ET+ST groups. Aerobic capacity increased for the ET and the ET+ST groups. All exercise groups displayed a significantly beneficial effect of exercise on time to the first fall using the cox regression analysis (relative hazard=0.53). This study suggests that exercise by itself affects risk of falling.

Finally, a controlled study conducted by Tinetti et al. (1993 &1994b) looked at the effectiveness of a multifactorial intervention in reducing the risk of falls among 301 community-dwelling older adults. The intervention subjects were given either an adjustment in their medications, behavioral instruction and/or exercise programming designed to modify their specific risks. Behavioral instruction included education on postural hypotension, sedative drugs, grab bars, etc. The exercise program involved graded levels of difficulty for strength and balance training. For example, the strengthening exercises increased in level of difficulty by advancing resistance of the Therabands used. Prescription for the exercise programs was twice a day for 20 minutes.

The primary outcome measure was incidence of falls. During a one year follow-up, fewer seniors in the intervention group (35%) fell, when compared to the control group (40%) ($p=0.04$). Among the subjects who had a particular risk factor at baseline, a smaller percentage of those in the intervention group than those in the control group still had the risk at reassessment, as follows: greater than 4 prescription medications, 63% versus 86% ($p=.009$); balance impairment, 21% versus 46% ($p=.001$); impairment in toilet-transfer skills, 49% versus 65% ($p=.05$); and gait impairment, 45% versus 62% ($p=.07$). Risk factor modification may explain the reduction in the number of falls. The results demonstrate the need for targeting multiple risk factors in the implementation of fall reduction interventions.

Summary

A number of intervention strategies are accessible for a fall prevention program. Conclusions from the majority of studies reveal that fall prevention education, exercise, and environmental modifications to be effective programming methods for reducing fall risk factors and/or the frequency of falls among older adults. However, none of the intervention strategies in the literature propose a program combining low intensity exercise, environmental modifications, and nutritional education. Future investigations should address intervention programs involving these three components, specifically the addition of nutrition interventions. National surveys indicate that 40-50% of older adults are at moderate to high risk for nutritional problems. And that an estimated 85% of non-institutionalized older adults have one or more chronic conditions that could improve with proper nutrition (Wallace, 1997).

CHAPTER 3

METHODOLOGY

Pilot Study

Prior to the implementation of the multifactorial fall prevention program, a pilot investigation was conducted to assess the efficacy of a low cost home-based exercise program designed by Kay Van Norman (1996). The study was initiated to evaluate the exercise portion of a multi-factor fall prevention program (Yates, Dunnagan, & Van Norman, 1998). The investigators used a one-group pretest-posttest pre-experimental research design. Eighteen seniors were recruited from Bozeman, Montana. The subjects were 83% female, 17% male, and had an average age of 77.3.

The subjects were given a variety of physical assessments prior to and following the 10 week exercise intervention. The test included (a) the arm curl test which evaluates muscular endurance and strength in the biceps, (b) the scratch test which evaluates upper body flexibility, (c) the get up and go test which evaluates mobility, agility, coordination, balance, and gait speed, (d) the chair stand which is designed to evaluate lower body strength and endurance, and (e) the Tinetti balance questionnaire which evaluates balance. The details of the arm curl test, scratch test, get up and go test, and the chair stand are detailed by Jones and Rikli (1997). The Tinetti balance test was developed by Tinetti and colleagues (1996).

During the intervention, the subjects kept a daily log of participation in each of the assigned activities (Appendix F). The subjects also received bi-weekly telephone calls to answer their questions about the exercise program. This data provided information related to subject adherence to the prescribed programming.

The exercise intervention, "Movement Matters," was a home-based program designed to maintain basic activities of daily living for senior populations (Van Norman, 1996). The intervention consisted of a series of chair-based and chair-assisted activities focused on improving coordination, balance, strength, and mobility.

The pretest and posttest data were described using descriptive statistics and student t-tests with an alpha set at 0.10. A statistically significant change was observed within the entire group for the arm curl test (p=0.0019). A similar trend was seen in the chair stand (p=0.12) and the scratch test (p=0.13). However, the change scores were not significant at the .10 level. No changes were observed in the scores for the get up and go test (p=0.49) or the Tinetti balance test (p=0.77) (Appendix H).

The subjects were divided into two groups to assess the difference between adheres and non-adheres to the exercise intervention. Those subjects (56%) who performed the exercises at least 12 times during the 10 week intervention were classified as exercise adheres. Subjects (44%) who exercised less than 12 times were classified as non-adheres. The t-tests showed that the exercise adheres showed more significant changes than the non-adheres. Specifically, significant changes were seen in the scratch test (p=0.08), arm curl test (p=0.031), and the get up and go test (p=0.015). The changes in the Tinetti balance test (p=0.14) and the chair stand test (p=0.11) did not show significant changes during the 10 week intervention at the 0.10 level (Appendix H).

This pilot study had several limitations. Specifically, the pre-test post-test pre-experimental research design has a number of weaknesses. Without the use of a control group, it is impossible to say if the changes in this investigation were due to the intervention, history, or maturation (Campbell, & Stanley, 1963). Also, the sample size limits the power of the analysis. It is important to consider these limitations when interpreting the results.

However, the pilot study did reveal a number of important factors that needed to be considered in the multifactorial fall-risk reduction intervention (Yates, S. et al., 1998). First, the differences found between exercise adheres and non-adheres supports a large body of literature which discusses the importance of exercise adherence in the facilitation of health enhancement through exercise (Dishman, 1998; Dunnagan, 1987; Shephard, 1985). Therefore, a logical step in refining this home-based exercise program would be to use appropriate adherence techniques to magnify the changes within senior populations. The pilot study also revealed the difficulty in recruiting older adults. Originally the pilot study called for 40 participants, but the researchers were only able to recruit 20 seniors. It became apparent that adequate recruitment time and numerous recruitment techniques would need to be employed for the multifactorial fall-risk reduction intervention. Also, select physical and psychometric evaluation measures were also modified for the fall prevention study. Specifically, the chair stand was eliminated and an assessment of leg power was added. Finally, the depression scale was changed to a shorter, less repetitive instrument.

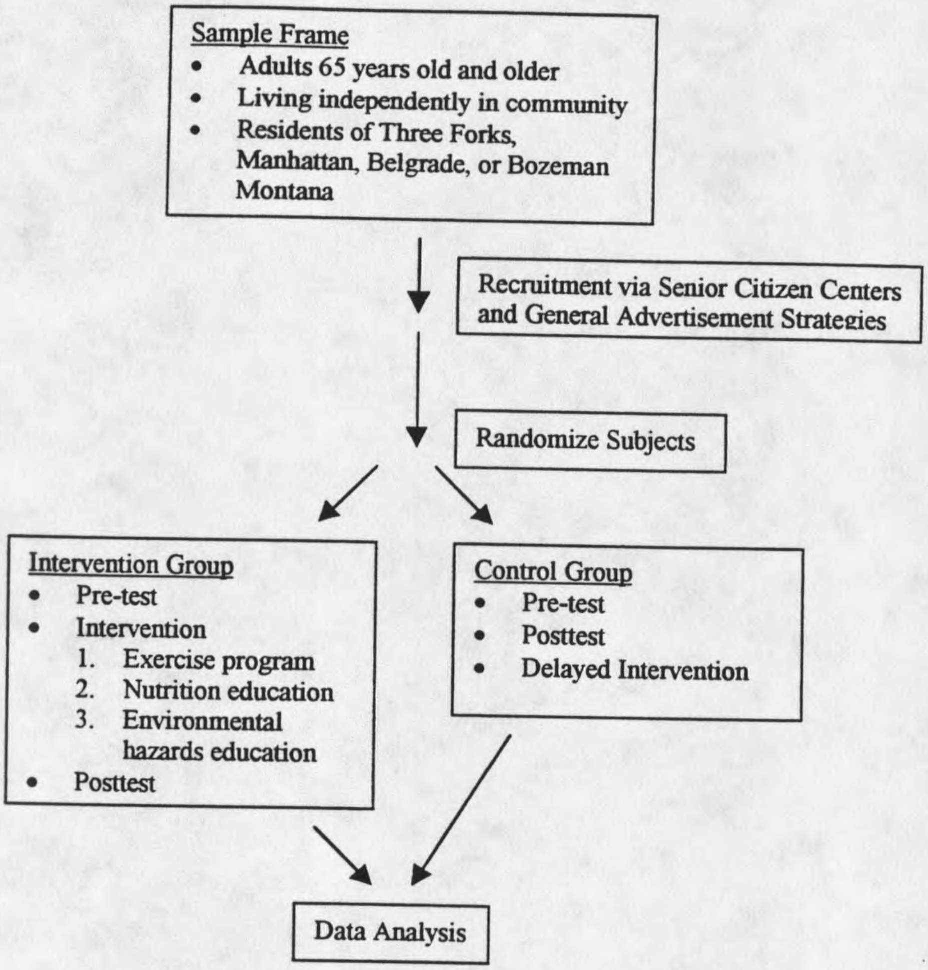
Multifactorial Intervention Research Design

The study was designed to evaluate the effects of a multifactorial home-based fall prevention program on select fall-related risk factors. This study follows a quasi-experimental pre-test post-test design (See Figure 3). The subjects were randomly assigned by alternating assignment to a treatment or delayed treatment group. All subjects were assessed prior to the intervention (pre-test) and following the 10-week intervention period (post-test). Each pre and post-test evaluation visit lasted an average of two hours and were conducted in the subjects' homes. The subjects were pre-tested in March, 1998 and post-tested in June, 1998. The experimental group received a three part intervention consisting of exercise programming, nutritional assessment and referral, and environmental hazards assessment and risk reduction education. The control group was idle for the 10 week intervention and received the intervention following the post-test assessments.

Human Subjects Committee Approval

A human subjects clearance form was submitted to the Montana State University Human Subjects Committee (HSC) on December 11, 1997 (Appendix B). The HSC approved the study procedures on January 14, 1998.

Figure 4: Schematic of Research Design



Recruitment of Subjects

Forty human subjects over the age of 65 were recruited from Three Forks, Manhattan, Belgrade, and Bozeman, MT. Specifically, the researcher visited each of the senior centers in these communities and presented the fall prevention research project. A brochure (Appendix C) describing the fall prevention intervention was given to older adults who participate in programs of the Three Forks Senior Citizen Club, the Manhattan

Senior Center, the Senior Citizen's Friendship Club of Belgrade, and the Bozeman Senior Citizen Center. Brochures were also given to the Three Forks area clergy, who agreed to distribute the information to seniors in their congregation. Next, a recruitment notice was distributed through the Three Forks newspaper and an article describing the entire fall prevention program was printed in the Prime Time News (a senior news publication). Last, a public service announcement was run on the area public broadcasting station (PBS) television channel. Consequently, the investigator used a variety of distribution channels to recruit older adults for the multifactorial fall prevention program.

The subjects were asked to sign an informed consent (Appendix D), as well as give permission to complete all testing procedures in their home. Physician's approval was obtained for each subject by the investigator by way of a release form through the mail (Appendix D). The subjects were randomly assigned to either the delayed treatment (control) or treatment group.

Instrumentation

During pre-testing and post-testing a seven page questionnaire was completed by the subjects with assistance from the investigator. After completing the questionnaire, the subjects performed a number of physical function assessments (Appendix E). The following is a synopsis of the self-rated health characteristics, psychometric, environmental, and functional measuring instruments used to assess the subjects' fall-related risk factors. Definitions for the fifteen fall-related risk factors used in calculating the cumulative fall risk for each subject is also provided.

Self-Rated Health Characteristics

Subjects were asked to rate their health on a number of characteristics. The self-rated health characteristics chosen for this study were all correlates of falls for older adults. Following are the definitions used to determine each health characteristic as a fall-related risk factor:

Poor Vision	individuals with glacouma or macular degeneration.
Poor Hearing	classified by the investigator for those subject's who had trouble hearing normal conversation. Basically, if things had to be repeated often or in an elevated voice.
Alcohol Use	consuming more than two alcoholic beverages daily.
Tobacco Use	current use of cigarettes, cigars, pipes, or smokeless tobacco.
High Blood Pressure	individuals who have or are being treated for high blood pressure or hypertension.
Hospitalization in past year	overnight in the hospital for any medical reason.
Sedentary	not engaging in some sort of physical activity three or more times a week for at least ten minutes per session; i.e. walking, gardening, biking.
Foot Problems	bunions, corns, long toe nails, foot deformities, and/or any other unusual problems with the feet.
Sedative Use	use of any over the counter or prescription medication to help them sleep.

Prescription Medications	list of all prescription medications currently using (4+ medications was considered a risk)

Psychometric Assessments

1.) Falls Efficacy Scale (5 minutes):

The Falls Efficacy Scale was developed by Tinetti (1990) to help determine the extent to which fear of falling exerts an independent effect on functional decline among older adults (Tinetti, Richman, & Powell, 1990). It is based on Bandura's theory of self-efficacy (Bandura, 1987). Self-efficacy is defined as a person's perception of his or her capabilities within a particular domain of activities. In this 10 question instrument, falls efficacy represents the degree of confidence a person has in performing the common activities of daily living. Subjects rate their confidence on a scale of 1-10; a score of 10 connotes the lowest level of confidence.

Example.

How confident are you that you can prepare a simple meal?

Not at all Confident	Fairly Confident	Completely Confident

2.) Depression Scale (5 minutes):

The depression scale is one dimension of the Hopkins Symptom Checklist (HSCL) (Derogatis, Lipman, Rickels, Uhlenhuth & Covi, 1974). Derogatis and associates determined this section of the questionnaire to have test re-test reliability of .81 and inter-rater reliability of .64. These results reveal this instrument to be dependable and consistent predictor of depression. The 11 question instrument measures symptoms of depression in the last two weeks. The subject's select one of five possible responses. The scores for the 11 questions were summed with the highest possible score being 55 and the lowest being 11. Lower scores are related to fewer depression symptoms.

Example.

In the last two weeks, how much were you bothered or distressed by feeling no interest in things?

Not at All	A Little Bit	Moderately	Quite a Bit	Extremely

<u>Nutrition Assessments</u>

3.) Nutritious Food Behavior Scale (5 minutes):

The Nutritious Food Behavior Scale comes from Rotter's Social Learning Theory of Personality and Dietary Behavior. It is used to measure the dependent variable of reported food behavior. This nine question instrument measures food selection and avoidance. The nine questions considered foods that act as a prophylaxis against nutritional related illness in the elderly. The subject's choose one of three responses. The scores for the nine questions were summed with the highest possible score being 27 and the lowest being 9. The higher the score the more nutritious the food behavior. Basically, subjects receive high scores if they try very hard to avoid salt, sugar, cholesterol, and excessive calories; frequently read labels on packaged items; and on a daily basis eat fruits and vegetables (Houts & Warland, 1989).

Example.

How hard do you try to avoid foods high in sugar?

Try Very Hard	Try Somewhat	Don't Worry About It

4.) Locus of Control for Nutrition (5 minutes):

Locus of Control for Nutrition also comes from Rotter's Social Theory of Personality and Dietary Behavior. It was designed to measure locus of control expectancies in food behavior. A person with an internal locus of control believes the desired outcome is within his/her control. A person who indicates an external locus of control believes the outcome is not within his/her control, but controlled by someone or something else. This five question instrument measures locus of control expectancies in food behavior. A summation of the five scores can range from five to fifteen. Those with an internal locus of control will score highest on the continuum and those with an external locus of control will score lowest. Scores from 5 through 12 represented the "externals", scores 13 and 14 were the low-range "internals", and a score of 15 represented a high "internal" (Houts & Warland, 1989).

Example.

If qualified health professionals recommend eating certain foods, how likely is it you'll try them?

Very Much	Somewhat	Not Very Much

Environmental Hazards Assessment

5.) In-Home Assessment (30 minutes):

The In-Home Assessment was developed by the investigator because there was no comprehensive environmental risk assessment available to researcher. It was compiled from the cited environmental risks in the literature (Cutson, 1994; Lange, 1996; Northridge, Nevitt, Kelsey, & Links, 1995; Sattin, Rodriquez, DeVito, & Wingo, 1998). This 40 question instrument measures environmental fall-related risk. The questions ask about various in-home hazards. A composite score of the number of environmental risk factors was determined by summing the total number of environmental risk factors. If the subject had more than four environmental risk factors within their home, they were considered to be at risk environmentally.

Example.

Is there a rug or rubber mat near the sink? ☐ Yes (1) ☐ No (0)

Physical Assessments

6.) Arm Curl (5 minutes):

This test is used to measure upper body bicep endurance. This test is similar to the AAHPERD arm curl test (Osness, Adrian, Clark, Hoeger, Rabb, & Wiswell, 1996). Test-retest reliability estimates for the arm curl test are .81 for males and .80 for females (Rikli & Jones, 1997). The subjects curl a 5 pound barbell through a full range of motion as many repetitions as possible during 30 seconds. The number of curls was counted and recorded.

7.) Scratch Test (5 minutes):

This test is used to determine overall shoulder range of motion. It is a modified version of Apley's scratch test, which has been used for years by therapists and orthopedic physicians as a quick evaluation for overall shoulder range of motion (Starkey & Ryan, 1996). Test-retest reliability estimates for the scratch test are .96 for males and .92 for females (Rikli & Jones, 1997). The subjects were asked to reach behind their head with one hand and behind the back with the other. They tried to touch their two middle fingers together behind the back. The distance between the two fingers was measured and recorded as a positive number. If the subject's fingers overlapped, their measurement was recorded as a negative number. The subjects were allowed one trial run prior to the actual measurement.

8.) Get Up and Go Test (5 minutes):

The Get Up and Go test was used to assess mobility, which involves gait speed, agility, balance and coordination (Mathias, Nayak, & Issacs, 1986). Get Up and Go performance has been found to be a significant predictor of falling (Tinetti, 1986a). This version of the Get Up and Go test has test-retest reliability estimates of .98 for males and .90 for females (Rikli & Jones, 1997). The test involves a chair with an eight foot course directly in front of the subject. The subject begins by sitting in the chair and upon the timers command rises from the chair and walks to the end of the eight foot course. After reaching the end of the course, the subject goes around a cone and returns to the chair in a seated position. This is a timed test and the subjects are allowed one practice run.

9.) Dorsiflexion of the ankles (2 minutes):

Measurement is taken to assess the flexibility of the ankle and determine if a subject is at risk for drop foot. Range of motion was determined in the basic planes by standard goniometric techniques (American Academy of Orthopedic Surgeons, 1965). The subjects foot was placed on a flexion board with an initial angle of measure at 104 degrees. They were asked to dorsiflex their foot and the final angle measured with a protractor. Two measurements were taken and averaged.

10.) Tinetti Balance Assessment (5 minutes):

Subjects began seated in a chair, they were asked to rise, make a 360 degree turn, close and open their eyes, and return to a seated position. The investigator assesses the subjects from 0=poor and unsafe, to 2=safe and steady on each of the nine questions. Subjects score between 0-16 with 16 being the best possible balance rating (Tinetti, 1986a).

11.) Power Test (5 minutes):

The power test was used to assess power of the lower extremities. The subjects were weighed on a bathroom scale provided by the researcher (F). Then their height was measured from a sitting position (H_1). The subject was then timed to see how long it takes to rise to a full standing position (t). Finally the height measurement upon standing was taken (H_2). Collectively, these measures were calculated to determine the subjects ability to generate power (Nm/sec) from a sitting to a standing position using the following formula for power:

$$\text{Power (P)} = \text{Force (F)} \{\text{Height}_2\ (H_2) - \text{Height}_1\ (H_1)\} / \text{Time (t)}$$

Cumulative Number of Fall-Related Risk Factors

Aside from assessing individual fall-related risk factors, the total number of risk factors were calculated for each subject and weighted equally. Definitions were taken from the literature when available or they were developed by the investigator using the mean score of the baseline data from each of the assessment measures. For example, the mean score for the baseline data of the depression scale was a score of 19. Subject's were cited as being at risk for depression if their score was greater than 19. Figure 5 lists the fifteen fall-related risk factors assessed in this study and their definitions.

Figure 5: Fall-related risk factors and benchmarks used to determine fall risk

Fall-related Risk Factor		**Definition of Being at Risk**
1.	Age	>80 years old[2]
2.	Low Social Support	living alone[2]
3.	Previous Falls	2+ previous falls[3]
4.	Depression	a score >19 on the depression scale[1]
5.	Fear of Falling	a Falls Efficacy Score <125[1]
6.	Environmental Hazards	4+ hazards[1]
7.	Polypharmacy	4+ prescription medications[2]
8.	Lack of Physical Activity	not engaging in 3 bouts of physical activity lasting 10 minutes or more[1]
9.	Poor balance	a score <14 on the Tinetti Balance Assessment[1]
10.	Lack of Bicep Muscular Endurance	arm curls <17 repetitions for males, and <13 repetitions for females[1]
11.	Poor Shoulder Flexibility	a score >8 inches[1]
12.	Poor Mobility	a score >6.2 seconds for males, and >7.4 seconds for females[1]
13.	Lack of Power in the Lower Extremities	a score <315 Nm/sec for males, and <153 Nm/sec for females[1]
14.	Low or High BMI	Males = 21.6<x<32.4 Females = 22<x<33[4]
15.	Sedative Use	any medication used for sleep or relaxation[2 3]

[1] Determined by the investigator using the mean score of baseline data.
[2] Hindmarsh & Estes, 1989
[3] Tinetti, Speechly & Ginter, 1988
[4] Cotton (Ed), 1998

Intervention

The intervention period lasted 10 weeks beginning immediately after pre-testing. The subjects received a three part intervention to help reduce their fall-related risk factors. The intervention consists of exercise programming, nutritional counseling and/or referral, and environmental hazard education. The subjects in the delayed treatment group (controls) received the same intervention as the subjects in the treatment group after the 10 week intervention period.

Exercise Program

Prior to the initiation of the exercise program, all of the subjects in the treatment group were briefed on the importance of fall prevention. The researcher spent 20 minutes with each subject talking about the association of falling with poor vision, poor hearing, sedative use, multiple medications, orthostatic hypotension, depression, and lack of physical activity. This time was used as a motivational piece for the exercise intervention, hopefully educating seniors about various fall-related risks and their role in reducing these factors.

The exercise program was to adhere to the guidelines of the Movement Matters: Home Based Exercise Program, by Kay Van Norman (1996) at least three times a week (Appendix F). The exercise program begins with four exercises for warm-up and coordination. They include the Toe Touch, the Heel Press, Side Toe Touch, and the Elevator. The second component of the program focuses on balance and involves four exercises. They include the Knee Lift, Knee Bends and Tip Toes, Heel to Toe Walks, and

Achilles Stretch. The last section is for strength and mobility and involves 10 exercises. They include the Ankle Flexion/Toe Curls, Knee Lifts with weights, Knee Extensions with weights, Reach and Squeeze, Hand Mobility, Finger Stretch, Shoulder Press with weights, Bicep Curl with weights, Cross Arm, and the Elbow Lift. Each exercise session took approximately 15 minutes once the subjects became comfortable with the routine. To facilitate muscular strength and endurance development, each subject was given a set of five pound weights. Log sheets were maintained by the researcher in order to track exercise compliance. The subjects recorded how often and at what intensity they performed the exercises (Appendix F).

Nutrition Counseling

The nutrition component of this intervention used the Nutritional Screening Initiative (1991), which is a multifaceted national effort to promote nutrition screening and better nutritional care for older adults. The subjects completed the Nutritional Health Checklist (Appendix G) and received a score ranging from 0 to 25. If their score was 3-5 they received a Level I screen. The Level I screen includes nutrition education in the form of hand-outs and a list of community resources that can provide help with nutrition. If their score was 6 or more they received a Level II screen. The Level II screen involves a referral to a registered dietician, who was contracted to work on this study.

Environmental Hazard Education

During the pre-test visit an environmental assessment of the subject's home was conducted by the investigator. Any of the environmental hazards identified were noted.

Based upon this analysis, safety modifications to the home environment were outlined for each subject. For example, if the hallway leading downstairs is steep and dimly lit, the suggested modifications included night lights and/or new bulbs in the overhead lights. It was also suggested that flourescent tape be placed on the first and last step in order to draw the subject's attention to these areas. The researcher also suggested that armrails be used and/or installed if they were absent. Each area of the subject's home that revealed hazards received a list of possible modifications.

Statistical Analysis

Data were entered into the statistical package Minitab 12. The data were cleaned by checking the possible values for each variable, for example, possible codes for gender were 1=male and 2=female. Each variable was checked to insure none of the values were outside of this range of scores. Dot plots were run to see if the distribution trends of the data. Box and whisker plots were run to show if there were any outliers for each variable at baseline, thus determining normal distribution. Next, descriptive statistics were done compare the two groups. Frequencies and percent distribution were calculated for age, gender, education, living arrangements, marital status, and number of falls. Frequencies and percent distribution were also calculated for the self-rated health characteristics: vision, hearing, alcohol use, tobacco use, sedative use, high blood pressure, hospitalization in the last year, physical activity, foot problems, and number of prescription medications. Chi squares and unpaired t-tests were run on baseline data for each of the descriptive characteristics to determine if there were any significant differences between the intervention and the delayed intervention groups.

Paired t-tests were performed to determine mean change scores for each dependent variable in relation to group designation. Also, unpaired t-tests were run to determine mean differences between groups. The physical characteristics used as dependent variables included: balance, ankle flexion, bicep endurance, upper body flexibility, mobility, and lower extremity power. The psychometric measures used as dependent variables included: fall efficacy, and depression. The nutrition measures used as dependent variables included: nutritious food behavior, and locus of control for nutrition. The total number of environmental hazards and the total number of fall-related risk factors were also classified as dependent variables. Statistical significance was determined at the .05 level of significance. However, this analysis tests fourteen independent contrasts (dependent variables) and the threat of making one or more type I errors increases sharply. At an $\alpha=0.05$ the probability of a significant result occurring due to chance alone is 1 in 20, however when the number of dependent variables is fourteen the probability increases to 1 in 2 or 50% of the time. As the number of independent test increases, so does the probability of obtaining spuriously significant results (Kirk, 1982). Hence, for this analysis the alpha was adjusted according to the Bonferroni inequality (Glass & Hopkins, 1996). Therefore, all of the t-tests were also tested using the more conservative Bonferroni inequality adjustment ($\alpha=0.0036$).

Simple Regression

Simple regression models were used to determine if group designation predicted the change in outcome variables. The physical characteristics used as dependent variables included: balance, ankle flexion, arm strength, upper body flexibility, mobility, and leg strength. The psychometric measures used as dependent variables included: fall efficacy and depression. The nutrition measures used as dependent variables included: nutritious food behavior, and locus of control for nutrition. The total number of environmental hazards and the total number of fall risk factors were also classified as dependent variables. Group designation was the sole independent variable used in the regression models. There were no additional independent variables added in the regression models, because the two groups were similar on all independent variables. Statistical significance was determined at the $\alpha = 0.05$ level of confidence.

CHAPTER 4

RESULTS

Introduction

The purpose of this chapter is to examine the effects of the fall prevention intervention on select risk factors. First, dot and box and whisker plots were constructed to show that the data were normally distributed. T-tests and chi squares where conducted on baseline data to compare the intervention and the delayed intervention groups. Next, paired t-tests were run to compare the mean change scores within groups. Unpaired t-tests were conducted to show the differences in mean scores between groups. Finally, regression models were used to determine if group designation predicted change in fourteen outcome variables. An $\alpha = 0.05$ was used throughout the analysis to determine statistical significance. Because multiple t-tests were used in this analysis, an adjusted level of significance (α=0.0036) according to the Bonferroni inequality was also used to determine statistical significance for the t-tests.

A total of 40 subjects over the age of 65 were recruited for the fall prevention study. One subject was excluded from the analysis due to a pre-existing illness (multiple sclerosis). Two subjects did not finish the study (5% Attrition). Consequently, the analysis is based on a sample of thirty-seven (N = 37) subjects (eighteen subjects in the intervention group and nineteen subjects in the delayed intervention group).

Adherence to the exercise program was defined as performing the exercises at least 12 times during the 10-week intervention. This study revealed an adherence of 72.2% for the intervention group. Each subject in the intervention group also received the Nutrition Screening Instrument (NSI) (1991), if their score was 6 or higher they were labeled as high risk for malnutrition. Upon completion of this tool, 11% (2) of the intervention group were classified as high risk. Protocol of the NSI suggested high risk individuals see a doctor or dietician. The subjects classified as high risk received referrals to a registered dietician, however, neither of the subjects contacted the dietician. Barriers reported for failure to contact the dietician included: lack of time and belief that nutrition was adequate.

Distribution of Scores

The first analysis of the data was to look at the distribution of scores for each variable. In order to use inferential statistics, it is important to show that the data is normally distributed (Glass & Hopkins, 1996). The dot plots in Figure 6 show the distribution of baseline data for the physical outcome variables. The plots for dorsiflexion left, dorsiflexion right, arm curl, and scratch test left demonstrate that the data were normally distributed. The plots for scratch test right, get up and go, and power were positively skewed. The plot for balance was negatively skewed. The dot plots in Figure 7 show the distribution of baseline data for environmental hazards, psychometric, nutrition behavior, and total number of fall-related risk factors outcome variables. The plots for environmental hazards, depression scores, and total number of risk factors demonstrate that the data were normally distributed. The plots for nutritious behavior and locus of control for nutrition were positively skewed. The plot for falls efficacy was negatively skewed.

Box and whisker plots were also run on the baseline data, in order to examine the distribution of scores. These plots are useful because they show outliers, which are values that fall above or below 1.5 times the value of the interquartile range (Glass & Hopkins, 1996). In order to analyze the data, the outliers must be addressed. Although some of the outcome variables were positively or negatively skewed, Figure 8 and Figure 9 show only the data for scratch test right has outliers which have dramatic impact on the group means. Baseline data for the scratch test right had two outliers which were three or more standard deviations above the mean (outside the outer fence). These outliers are shown as circles on the box and whisker plots (Figure 8). Both of these data points were from participants in the delayed intervention group. For purposes of this analysis these two scores were removed from the scratch test right t-tests and regression analysis, in order to meet the assumption of homogeneity of variance and normal distribution of scores. The values shown as asterisks on the box and whisker plots are possible outliers. These data points fall between two and three standard deviations above or below the mean. Outcome variables with these outliers should be evaluated carefully, but may still be analyzed using inferential statistics.

Figure 6: Dot plots of physical outcome variables at baseline.

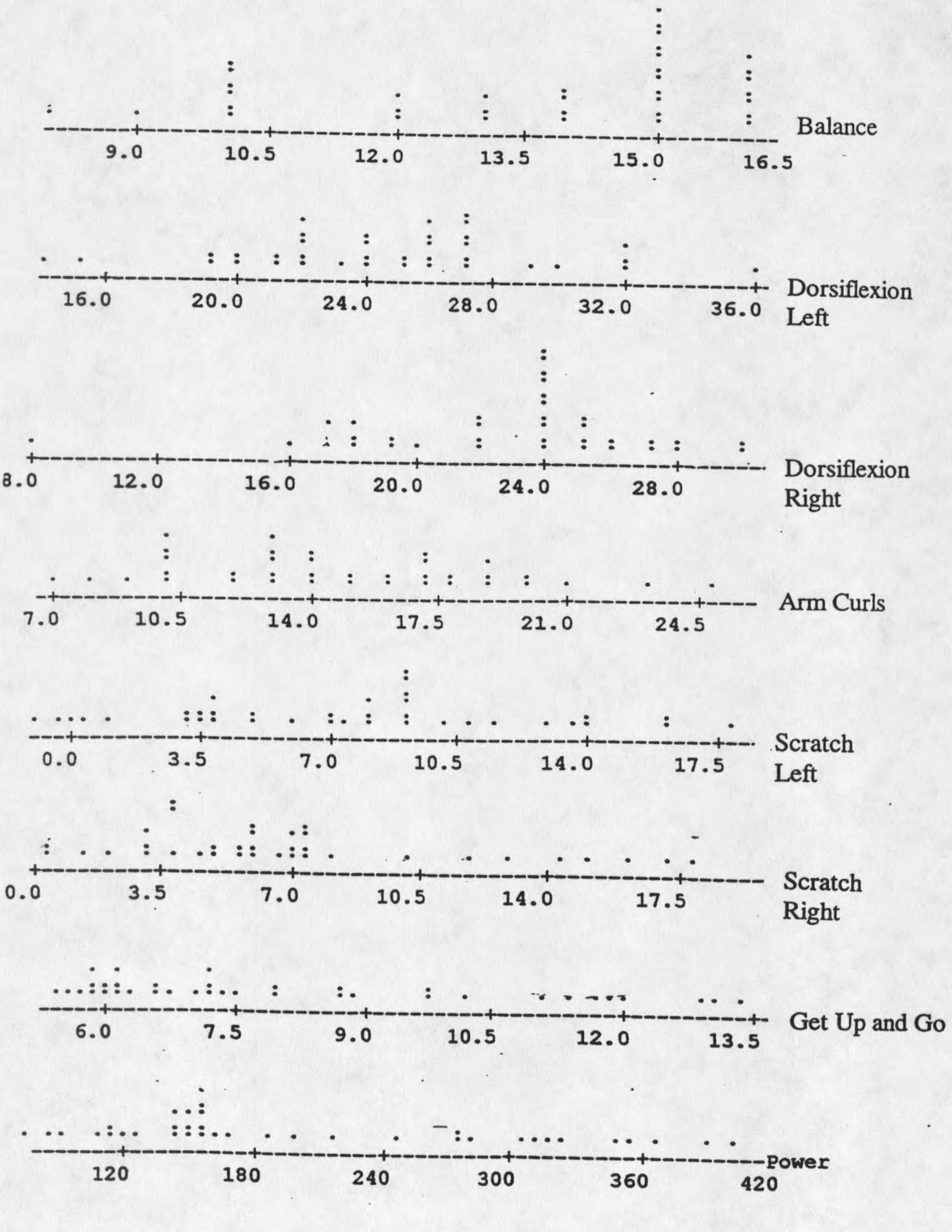


Figure 7: Dot plots of environmental hazards, psychometric, nutrition behavior, and total fall-related risk factor outcome variables at baseline.

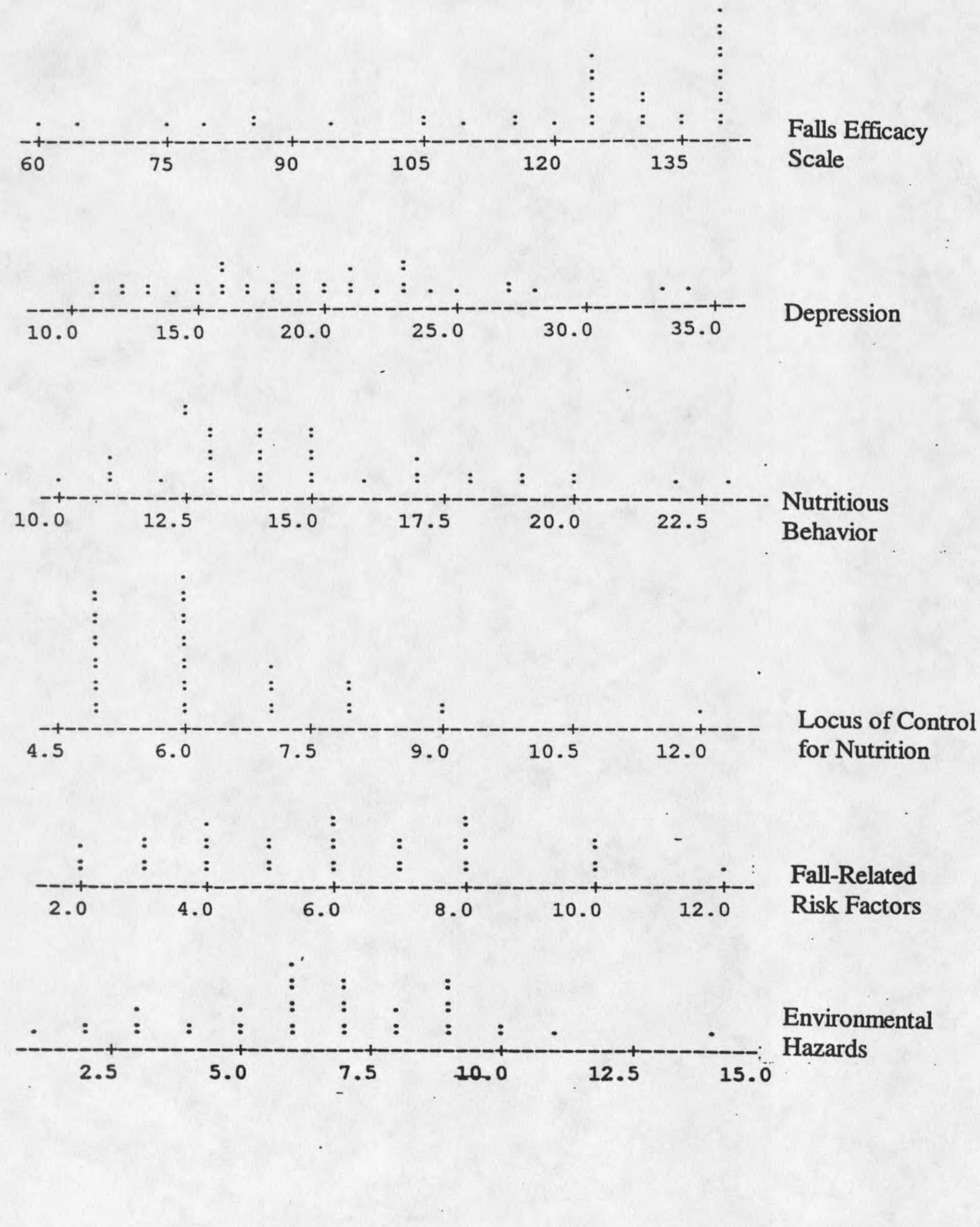
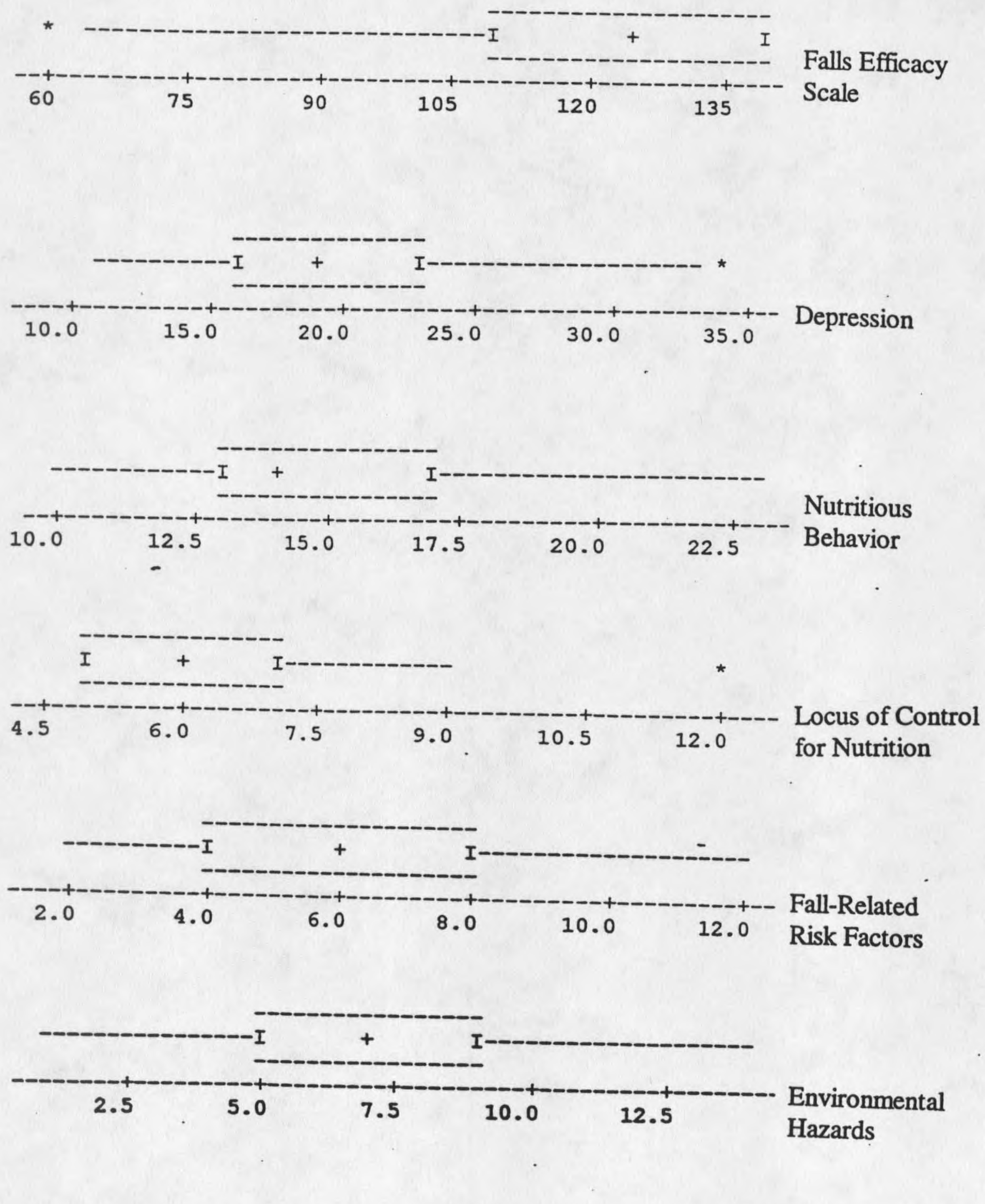


Figure 8: Box and whisker plots of the physical outcome variables at baseline.

```
                                     ---------------------
     ----------------------------I             +         I-------
                                     ---------------------
    -------+---------+---------+---------+---------+-------  Balance
         9.0      10.5      12.0      13.5      15.0

                                 ---------------
    *     -------------------I        +       I--------------
                                 ---------------
  --+---------+---------+---------+---------+---------+---  Dorsiflexion
  14.0      17.5      21.0      24.5      28.0      31.5    Left

                                     ----------------
  *                      --------I             + I------------
                                     ----------------
  +---------+---------+---------+---------+---------+-----  Dorsiflexion
 8.0      12.0      16.0      20.0      24.0      28.0      Right

                         ------------------
     --------------I      +        I--------------------
                         ------------------
  --+---------+---------+---------+---------+---------+---  Arm Curls
   7.0      10.5      14.0      17.5      21.0      24.5

                        -------------------
     ---------------I           +      I---------------------
                        -------------------
   ----+---------+---------+---------+---------+---------+  Scratch
      0.0      3.5       7.0      10.5      14.0      17.5  Left

                       ---------
     -------------I  +      I-------------   *    * *  *  O O
                       ---------
  +---------+---------+---------+---------+---------+-----  Scratch
 0.0       3.5       7.0      10.5      14.0      17.5      Right

                ------------------------
     -----I    +                       I-----------------------
                ------------------------
   ------+---------+---------+---------+---------+---------+  Get Up and Go
        6.0       7.5       9.0      10.5      12.0      13.5

                    ------------------------
   ------------I +                       I-------------------
                    ------------------------
   --------+---------+---------+---------+---------+-------  Power
          120       180       240       300       360
```

Figure 9: Box and whisker plots of the environmental hazards, psychometric, nutrition behavior, and total fall-related risk factor outcome variables at baseline.



Demographic and Health Characteristics

This section discusses the demographic and health characteristics of the study sample, providing relevant comparisons between the intervention group and the delayed intervention group. The purpose of this analysis was to see if the intervention and delayed intervention groups were similar. To this end, frequencies and percent distributions of demographics are shown in Table1.

The two groups are very similar when compared by age, gender, education, marital status and living arrangements. The average age of the intervention group is 76.67 years old compared to an average of 78.21 years old for the delayed intervention group. The intervention group consisted of 72.2% percent female subjects compared to 68.4% females in the delayed intervention group. This sample of older adults was well educated with 83.3% of the intervention group having completed high school compared to 73.68% of the delayed intervention group. The intervention group reported 61.1% of the subjects as married and 33.3% of the subjects as widowed, none of the subjects were divorced and one was single. The delayed intervention group reported 36.8% of the subjects as married and 57.9% of the subjects as widowed, none of the subjects were divorced and one was single. Subjects were also classified as either living alone or with someone. Living alone has been cited in the fall prevention research as a risk factor for falls (Cwikel, 1992). The data reveal 44.4% of the intervention group and 52.63% of the delayed intervention live alone.

The two groups were also similar in the number of reported falls. The intervention group reported that 22.2% of the subjects fell in the last month, compared to 21.1% in the delayed intervention group. Chi square analysis and unpaired t-tests were run to determine if any of the baseline differences between groups were statistically significant at $\alpha = 0.05$ (see Appendix I). The groups were found to be similar on age, gender, education, marital status, living arrangements, and fall status.

Table 1: Demographics of the intervention group and the delayed intervention group.

Variable	**Intervention Group N = 18**	**Delayed Intervention Group N = 19**
Age	76.67 ± 6.8 (67 - 90)	78.21 ± 4.61 (69 - 88)
Gender		
Male	27.8% (5)	31.6% (6)
Female	72.2% (13)	68.4% (13)
Education		
Completed High School	83.33% (15)	73.68% (14)
Did not complete	16.67% (3)	26.32% (5)
Marital Status		
Single	5.56% (1)	5.26% (1)
Married	61.11% (11)	36.84% (7)
Widowed	33.33% (6)	57.89% (11)
Divorced	0%	0%
Living Arrangements		
With Someone	55.56% (10)	47.39% (9)
Alone	44.44% (8)	52.63% (10)
Fell in the Last Month		
Yes	22.2% (4)	21.1% (4)
No	77.8% (14)	78.9% (15)
Average Number of Fall-Related Risk Factors	5.78 ± 1.93 (3-10)	6.21 ± 3.08 (2-12)

Information was also gathered on self-rated health characteristics. The literature on falls shows that many of these characteristics are related to increased fall risk. Frequencies and percent distributions of health characteristics are shown in Table 2. The health characteristics describing health status include: vision, hearing, high blood pressure, hospitalization, foot problems, number of medications, and total number of fall-related risk factors. The most notable difference between groups was for self-reported "poor" vision. The intervention group reported 27.78% with "poor" vision compared to 57.89% of the delayed intervention group. "Poor" hearing was reported by 38.89% of the intervention group and by 21.05% of the delayed intervention group. High blood pressure or controlled high blood pressure was reported by 55.56% of the intervention group and by 52.63% of the delayed intervention group. Only 11.11% of the intervention group and 15.79% of the delayed intervention group had been hospitalized in the last year. Problems with the feet, such as bunions, corns and long toenails have been shown as a risk factor for falling. For this sample of older adults, 33.33% of the intervention group and 36.84% of the delayed intervention group reported some kind of problem with their feet.

Older adults often take a number of medications for chronic health problems, this is known as polypharmacy. Multiple medications can be a source of fall risk due to drug interactions (Gray, S.L., 1997). On average this sample of older adults was not taking an exceptional number of medications; the intervention group reported an average 3.56 medications and the delayed intervention group reported 3.68 medications.

Last, a cumulative risk factor score was assigned to each subject based on the definitions in Figure 4. The total number of fall-related risk factors were calculated for each subject and weighted equally. For example, subjects over the age of 80, living alone, having 2 or more previous falls, and 4 or more environmental hazards would receive a cumulative risk factor score of 4. Cumulative risk takes into account the demographic, physical, environmental, and psychological risk factors assessed in this study. The intervention group reported an average of 5.78 fall-related risk factors compared to an average of 6.21 for the delayed intervention group. Chi square analysis and unpaired t-tests were conducted to determine if any of the baseline differences between groups were statistically significant at $\alpha = 0.05$ (Appendix I). The groups were similar on all health status characteristics.

The health characteristics describing health behaviors included: alcohol use, tobacco use, sedative use, and physical activity. This sample of older adults had a very low reported use of alcohol and smoking behavior. Only 5.6% of the intervention group reported drinking 2 or more drinks daily compared to 10.53% of the delayed intervention group. The intervention group reported no smokers and the delayed intervention group reported one smoker or 5.26% of the group. Sedative use has been cited as a very important risk factor in determining falls in the elderly (Tinetti, et al., 1988). Sedatives were reportedly used by 44.44% of the intervention subjects and 36.84% of the delayed intervention subjects. Overall this group reported a high percentage of physically active individuals. The intervention group reported 77.78% of the subjects performed some form of physical activity at least three times a week for 10 minutes compared to 68.42% of the delayed intervention group. The majority of the subjects reported walking or gardening as their physical activity and much of this was done only during the warmer months of the year. Chi square analysis and unpaired t-tests were run to determine if any of the baseline differences between groups were statistically significant at $\alpha = 0.05$ (Appendix I). The groups were similar on all health behavior characteristics.

Table 2: Percent and frequency of self-reported health characteristics by intervention group and delayed intervention group.

	Intervention Group N = 18		**Delayed Intervention Group N = 19**	
Health characteristics	Yes	No	Yes	No
Poor Vision	27.78% (5)	72.22% (13)	57.89% (11)	42.11% (8)
Poor Hearing	38.89% (7)	61.11% (11)	21.05% (4)	78.95% (15)
High Blood Pressure	55.56% (10)	44.44% (8)	52.63% (10)	47.37% (9)
Hospitalization in the Last Year	11.11% (2)	88.89% (16)	15.79% (3)	84.21% (16)
Foot Problems	33.33% (6)	66.67% (12)	36.84% (7)	63.16% (12)
Average No. of Medications Using (range)	3.56 ± 1.72 (1-8)		3.68 ± 2.40 (0-10)	
Average No. of Fall-Related Risk Factors (range)	5.78 ± 1.93 (3-10)		6.21 ± 3.08 (2-12)	
Alcohol Use	5.6% (1)	94.44% (17)	10.53% (2)	89.47% (17)
Smokers	0% (0)	100% (18)	5.26% (1)	94.74% (18)
Sedative Use	44.44% (8)	55.56% (10)	36.84% (7)	63.16% (12)
Physically Active (3x/wk for 10min.)	77.78% (14)	22.22% (4)	68.42% (13)	31.58% (6)

T-tests of Mean Change Scores Within Groups

Assuming homogeneity of variance (Glass & Hopkins, 1996), t-tests comparing pre-test and post-test means were conducted for the physical and psychometric outcome variables in each group. Table 3 displays t-tests of mean change scores within groups for the physical assessments. This analysis tests the null hypothesis that the mean change scores within group is different than zero. Scores are considered statistically significant at $\alpha = 0.05$. Because the chance of one or more type I errors increases when multiple t-tests are conducted, the results of statistical significance are also reported according to the Bonferroni inequality α=0.0036.

The mean balance score increased 1.44 points for the intervention group (p=.002), however, the delayed intervention group revealed a 0.74 point decrease from pre-test to post-test (p=.015). This change is statistically significant for both groups, but the change for the delayed intervention group showed a significant decrease in balance. The mean change score for the intervention group was also significant for the Bonferroni adjusted alpha.

The changes in ankle flexibility (Dorsiflexion Left and Right) did not reveal statistical significance for either group. However, ankle flexion did increase slightly for the intervention group, and decreased for the delayed intervention group. The mean score for Dorsiflexion left increased by 0.94 points in the intervention group (p=.129) and decreased by 0.53 points in the delayed intervention group (p=.58). The mean score for Dorsiflexion right increased by 0.67 points in the intervention group (p=.321) and decreased by 0.11 points in the delayed intervention group (p=.867). None of the changes were significant for either level of significance.

The mean change in arm curls for the intervention group was an increase of 3.33 repetitions, while the delayed intervention group decreased by 0.74 repetitions between the pre and post-test evaluations. Consequently, the change in dominant arm bicep endurance was statistically significant at both levels of significance for the intervention group (p = .001), while the change in the delayed intervention group was not statistically significant (p=.21).

Upper body flexibility (Scratch Test Left and Right) increased significantly for the intervention group in between the pre and post-test evaluations. The average change was a decrease of 1.44 inches on the left side (p=.015) and of 1.77 inches on the right side (p=.002) for the intervention group. The average change for the right side was also statistically significant when compared to the Bonferroni adjusted alpha. The delayed intervention group revealed an average decrease of 0.55 inches on the left side (p=.413) and an average increase of 1.25 inches on the right side (p=.198). The changes for the delayed intervention group were not significant for the left or the right side.

The mobility test (GUGT) did not reveal statistically significant changes for either group. However, the mean number of seconds it took the subjects in the intervention group to complete the mobility course decreased by 0.28 seconds (p=.193) and increased for the delayed intervention group by 0.37 seconds (p=.11).

The final physical assessment measured power from sitting to standing. The intervention group revealed a statistically significant increase in the mean of 34.2 Nm/sec (p=.005), while the delayed intervention had a decrease of 16.4 Nm/sec. (p=.125). However, the changes in power were not statistically significant when compared to the Bonferroni adjusted alpha.

In total, a statistically significant change was observed within the intervention group for balance (p = .002), bicep endurance (p = .001), lower extremity power (p = .005), and upper body flexibility (p = .015) at an α = .05. Also statistically significant changes were observed within the intervention group for balance (p = .002) and bicep endurance (p = .002) at the Bonferroni α=.0036. There were no statistically significant changes in the favorable direction observed within the delayed intervention group.

Table 4 displays t-test of mean change scores within groups for environmental hazards and total fall-related risk factors. The intervention group showed a 1.39 average decrease in the number of environmental hazards found within the subjects' home (p=.0000). The mean change in environmental hazards for the intervention group was also statistically significant when compared to the Bonferroni adjusted alpha. The delayed intervention also showed a slight decrease (0.26) in the mean score from pre-test to post-test, although the change was not statistically significant (p=.172).

Each subject was also assigned a cumulative risk factor score based on the following fall-related risk factors: age, social support, fall history, depression, falls efficacy, environmental hazards, medication use, physical activity, balance, bicep endurance, lower extremity power, upper body flexibility, mobility, BMI, and sedative use. The definitions for each factor are provided in Figure 4, page 36. The average total number of fall-related risk factors decreased by 2.11 risks in the intervention group (p=.000) and increased by 0.47 risks in the delayed intervention group (p=.187). The mean changes observed in the intervention group were statistically significant at both level of significance.

Table 3: T-tests of mean change scores within group for the physical assessments.

	Intervention Group					Delayed Intervention Group				
Outcome Variable	N	Mean[1]	Stnd Dev	T St	P Val	N	Mean[1]	Stnd Dev	T St	P Val
TAT (Balance)(+)	**18**	**1.44**	**1.69**	**-3.6**	**.002[2 3]**	19	-0.74	1.19	2.69	**.015[2]**
Dorsiflex-Left (+)	18	0.94	2.51	-1.6	.129	19	-0.53	4.07	0.56	.58
Dorsiflex-Right (+)	18	0.67	2.77	-1.0	.321	19	-0.11	2.70	0.17	.867
Arm Curl (+)	**18**	**3.33**	**3.61**	**-3.9**	**.001[2 3]**	19	-0.74	2.47	1.30	.21
Scratch-Left (-)	**18**	**-1.44**	**2.25**	**2.7**	**.015[2]**	19	-0.55	2.87	0.84	.413
Scratch-Right (-)	**17**	**-1.77**	**1.93**	**3.7**	**.002[2 3]**	16	1.25	3.71	1.35	.198
GUGT (-)	18	-0.28	0.89	1.4	.193	19	0.37	0.96	-1.6	.11
Power (+)	**18**	**34.2**	**45.6**	**3.2**	**.005[2]**	19	-16.4	44.3	-1.1	.125

[1] Change in Mean = Post-test Evaluation - Pre-test Evaluation.
[2] Statistically significant at $\alpha = 0.05$
[3] Statistically significant changes at the Bonferroni adjusted α=.0036
\+ A positive mean change score represents a change in the favorable direction.
\- A minus mean change score represents a change in the favorable direction.

In summary, a statistically significant change was observed within the intervention group for number of environmental hazards and change in total number of fall risk factors at both levels of significance. There were no statistically significant changes within the delayed intervention group for these two outcome variables.

Table 4: T-tests of mean change scores within group for the environmental hazards and total fall-related risk factors.

	Intervention Group					Delayed Intervention Group				
Outcome Variable	N	Mean[1]	Stnd Dev	T St	P Val	N	Mean[1]	Stnd Dev	T St	P Val
Environment (-)	**18**	**-1.39**	**1.34**	**-4.4**	**.0000**[2 3]	19	-0.26	0.81	-1.4	.172
Total Number of Fall Risk Factors (-)	**18**	**-2.11**	**1.83**	**-7.6**	**0.000**[2 3]	19	0.47	1.50	1.37	0.187

[1] Change in Mean = Post-test Evaluation - Pre-test Evaluation.
[2] Statistically significant at $\alpha = 0.05$
[3] Statistically significant changes at the Bonferroni adjusted α=.0036
\+ A positive mean change score represents a change in the favorable direction.
\- A minus mean change score represents a change in the favorable direction.

Table 5 displays t-test of mean change scores within groups for the psychometric and nutrition behavior measures. The Falls Efficacy scores range from 0-140 and measure confidence in performing the activities of daily living. The intervention group had a significant mean increase of 5.56 points between pre and post-test evaluations (p=.042). The delayed intervention group actually decreased in mean score by 0.53 points which was not statistically significant (p=.830). Neither mean change score was statistically significant at the Bonferroni adjusted alpha.

The depression scale did not reveal significant changes for either group. The mean change score within the intervention group decreased by 1.17 for the measure of depression, however this was not a statistically significant change at either level of significance (p=.280). The delayed intervention group also had a decrease in the mean change score of 0.95 points, but this change was also not significant (p=.454). Scores for the Depression Scale can range from 11 to 55.

The measures for nutritious behavior and locus of control for nutrition did not reveal significant changes at either level of significance within either the intervention or the delayed intervention group. The mean change score for nutritious behavior decreased by 1.33 points for the intervention group (p=.067) and increased by 0.84 points for the delayed intervention group (p=.100). Scores for the Nutritious Food Behavior Scale can range from 9 to 27. The mean change score for locus of control for nutrition increased by 0.167 points for the intervention group (p=.644) and increased by 0.474 points in the delayed intervention group (p=.107). Scores for the Locus of Control for Nutrition can range from 5 to 15.

In summary, a statistically significant change was observed within the intervention group for only the falls efficacy score (p = .042) when compared to an α=.05. However, when compared to the Bonferroni adjusted alpha the result was no longer statistically significant. There were no statistically significant changes in the favorable direction observed within the delayed intervention group.

Table 5: T-test of mean change scores within group for psychometric measures and nutrition behavior.

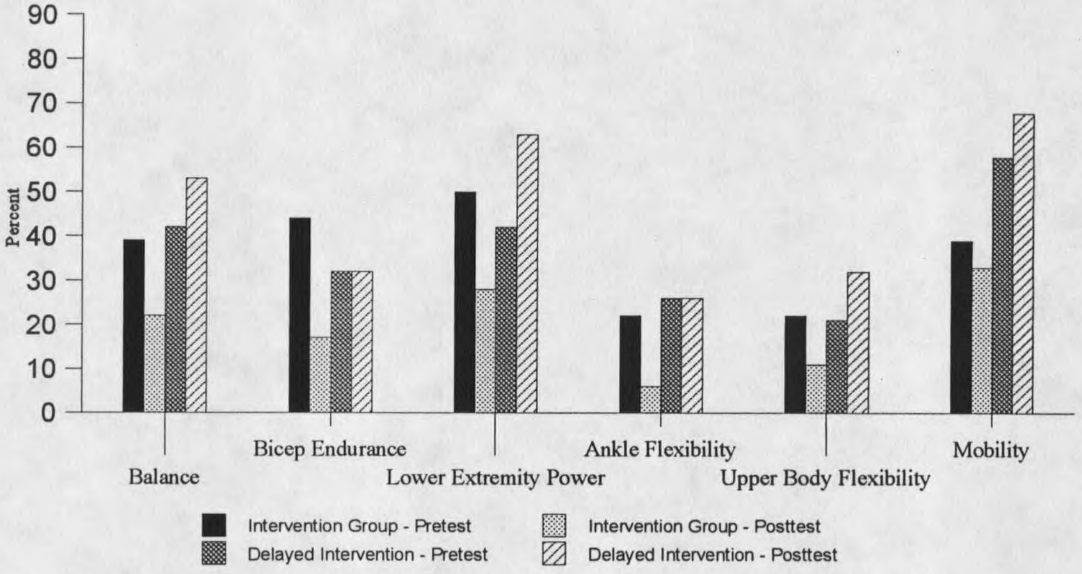
	Intervention Group					Delayed Intervention Group				
Outcome Variable	N	Mean[1]	Stnd Dev	T St	P Val	N	Mean[1]	Stnd Dev	T St	P Val
Falls Efficacy Score (+)	**18**	**5.56**	**10.7**	**2.2**	**.042[2]**	19	-0.53	10.5	-0.2	.830
Depression (-)	18	-1.17	4.44	-1.1	.280	19	-0.95	5.4	-0.8	.454
Nutritious Food Behavior (-)	18	-1.33	2.89	-1.9	.067	19	0.842	2.12	1.74	.100
Locus of Control for Nutrition (-)	18	0.167	1.51	0.47	.644	19	0.474	1.22	1.69	.107

[1] Change in Mean = Post-test Evaluation - Pre-test Evaluation.
[2] Statistical significance at $\alpha = 0.05$
There are no statistical significant result at the Bonferroni α=.0036.
+ A positive mean change score represents a change in the favorable direction.
- A minus mean change score represents a change in the favorable direction.

<u>Percent of Subject's with Each of the Fall Risk Factors</u>

Each of the physical, environmental, and psychometric outcome variables were defined as risk factors for falling. Figure 10 displays the percentage of subjects at pre-test and post-test who are at risk for each of the physical risk factors. There was a decrease in poor balance for the intervention group from 39% to 22%, while the delayed intervention group experienced an increase in the percentage with poor balance (42% to 53%). The percentage of subjects in the intervention group with poor bicep endurance decreased from 44% to 17%, while the delayed intervention group maintained at 32%. The percentage in the intervention group with poor lower extremity power decreased from 50% to 28%, while the delayed intervention group increased from 42% to 63%. Poor

Figure 10: Delayed and intervention group percentage of subjects at pre-test and post-test who are at risk for select physical risk factors.



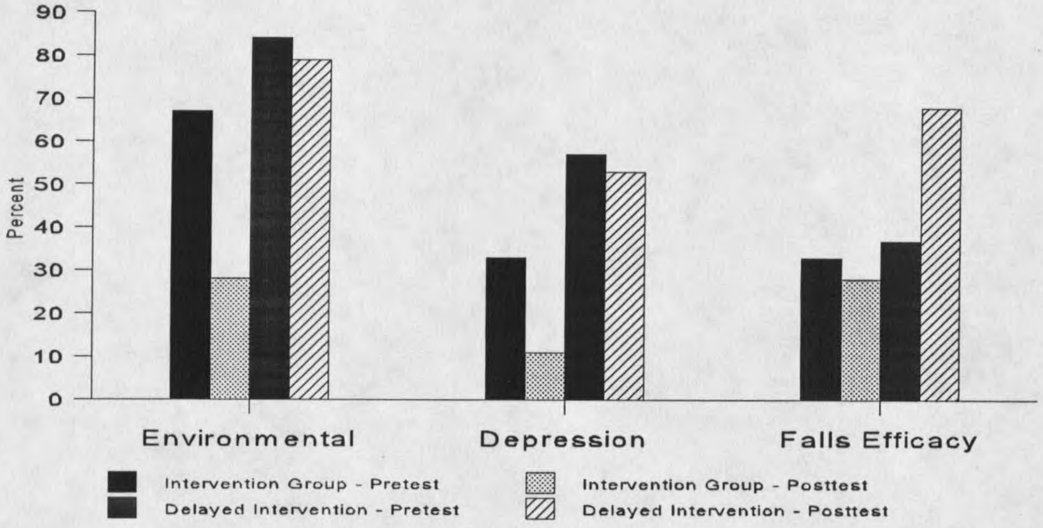
ankle flexibility was a risk factor for 22% of the intervention group at pre-test, but was reduced to 6% following the intervention. The delayed intervention group revealed 26% of the subjects to have poor ankle flexibility at both the pre and post-test evaluations. The percent of participants in the intervention group with poor upper body flexibility decreased from 22% at pre-test to 11% at post-test. The delayed intervention group saw an increase in the percentage of subjects with poor upper body flexibility (21% to 32%). Finally, poor mobility in the intervention group decreased from 39% to 33%, while the delayed intervention group had an increase in the percentage of subjects with poor mobility (58%

to 68%).

Figure 11 displays the percentage of subjects at pre-test and post-test who are at risk for the environmental and psychometric risk factors. The percentage of subjects in the intervention group with more than four environmental hazards decreased from 67% to 28% during the ten week intervention. In fact, seventy-two percent of the subjects in the intervention group reduced at least one environmental risk factor during the intervention period. The delayed intervention group had 84% of the subjects with more than four environmental risk factors at the pre-test and 79% at post-test. The percentage of subjects in the intervention group displaying symptoms of depression went from 33% at pre-test to 11% at post-test. The delayed intervention group had 57% of the subjects with depression symptoms at pre-test and 53% at post-test. The Falls Efficacy Scale, which has been associated with fear of falling, revealed a decrease in the fear of falling among the intervention group (33% at pre-test to 28% at post-test) and an increase among the delayed intervention group (37% at pre-test to 68% at post-test).

In summary, the results reveal a reduction in the percentage of persons in the intervention group with each of the following risk factors: poor balance, lack arm bicep endurance, lower extremity power, poor upper body and ankle flexibility, poor mobility, greater than four environmental risk factors, depression symptoms, and fear of falling. Conversely, the delayed intervention group revealed an increased percentage of persons with select fall-related risk factors.

Figure 11: Delayed and intervention group percentage of subjects at pre-test and post-test who are at risk for psychometric and environmental risk factors.



T-tests of Mean Change Scores Between Groups

T-tests comparing mean change scores between groups were conducted for the physical and psychometric outcome variables. Table 6 displays t-test of mean change scores between groups for the physical assessments. This analysis tests the null hypothesis that the difference between the two mean change scores is not equal to zero. Scores are considered statistically significant at $\alpha = 0.05$. The results of statistical significance are also reported according to the Bonferroni inequality α=0.0036.

Improved scores on the Tinetti Balance Assessment are associated with improved balance. The difference in mean change scores between groups was statistically significant for balance at both levels of significance (p=.0001). The mean change score for the intervention group was an increase of 1.44 points and for the delayed intervention group was a decrease of 0.74 points. The scores for the Tinetti Balance Assessment range from 0 to 16.

Improved scores for Dorsiflexion revealed an increase in ankle flexion. Specifically, the mean change score for the intervention group did increase by 0.94 degrees on the left and 0.67 degrees on the right. However, the analysis showed that the mean change scores between groups were not statistically significant for the left (p=.19) or right (p=.40) ankles. The delayed intervention group saw a decrease in mean change scores for both the left ankle (0.53 degrees) and the right ankle (0.11).

An increase in bicep endurance is associated with an increase in the number of arm curls performed in thirty seconds for this study. The mean number of arm curls increased for the intervention group by 3.33 repetitions and decreased for the delayed intervention group by 0.74 repetitions. This difference between groups was statistically significant at both levels of significance (p=.0004).

A decrease in scores for the Scratch Test revealed an increase in upper body flexibility. However, the difference in mean change scores between groups was not statistically significant for either left (p=.30) or the right (p=.62) arm in this analysis. The mean change scores for the intervention group increased by 1.44 inches on the left and 1.76 inches on the right. Also, the mean change scores for the delayed intervention group increased by 0.55 inches on the left and 1.25 inches on the right.

A decrease in the time it takes a person to complete the Get Up and Go Test is associated with increased mobility. The mean number of seconds it took the subjects of the intervention group to complete the Get Up and Go Test decreased by 0.28 seconds.

In the delayed intervention group the mean change score increased by 0.37 seconds. The difference between mean change scores for the two groups was statistically significant at an α=.05 (p=.039). However, it was not significant when compared to the Bonferroni adjusted alpha.

In this analysis, increased power is associated with an increase in lower extremity power. The mean change in power for the intervention group increased by 34.2 Nm/sec and decreased by 16.4 Nm/sec for the delayed intervention group. The mean difference between groups was significant at both levels of significance for the measure of power (p=.0017).

In summary, mean change scores between groups were significant for balance (p=0.0001), bicep endurance (p=0.0004), mobility (p=0.039), and lower extremity power (p=0.0017) at an α=.05. When compared to the Bonferroni adjusted α=.0036 the mean change scores between groups were significant for balance, bicep endurance, and lower extremity power. However, the mean change scores between groups were not significant for the scratch test or dorsiflexion.

Table 6: T-tests of mean change scores between groups for the physical assessments.

Outcome Variable	Means Change Score for Intervention Group[1]	Means Change Score for Delayed Intervention Group[1]	T St	P-Value
TAT (+)	**1.44**	**-0.74**	**4.51**	**0.0001[2,3]**
Dorsiflex- Left (+)	0.94	-0.53	1.33	0.19
Dorsiflex- Right (+)	0.67	-0.11	0.86	0.40
Arm Curl (+)	**3.33**	**-0.74**	**3.98**	**0.0004[2,3]**
Scratch- Left (-)	1.44	0.55	1.05	0.30
Scratch- Right (-)	1.76	1.25	0.50	0.62
GUGT (-)	**-0.28**	**0.37**	**2.15**	**0.039[2]**
Power (+)	**34.2**	**-16.4**	**3.42**	**0.0017[2,3]**

[1] Change in Mean = Post-test Evaluation - Pre-test Evaluation.
[2] Statistical significance at $\alpha = 0.05$
[3] Statistically significant changes at the Bonferroni adjusted α=.0036
\+ A positive mean change score represents a change in the favorable direction.
\- A minus mean change score represents a change in the favorable direction.

Table 7 displays t-test of mean change scores between groups for the environmental hazards and the total number of fall-related risk factors. The average number of environmental hazards decreased for the intervention group by 1.39 hazards and in the delayed intervention group by 0.26 hazards. The difference in mean change scores between groups was significant at an α=.05 (p=.005). However, when the difference in mean change scores between groups was compared to the Bonferroni adjusted alpha it was no longer statistically significant.

For each of the subjects a total number of fall risk factors was calculated. The results revealed a decrease in total fall risk factors of 2.11 risks for the intervention group and an increase of 0.47 risks for the delayed intervention group. The mean difference between groups was significant at both levels of significance (p=.000).

Table 7: T-tests of mean change scores between groups for environmental hazards and total fall-related risk factors

Outcome Variable	Means Change Score for Intervention Group[1]	Means Change Score for Delayed Intervention Group[1]	T St	P-Value
Environmental Hazards (-)	**-1.39**	**-0.26**	**3.09**	**0.005[2]**
Total Number of Fall Risk Factors (-)	**-2.11**	**0.47**	**5.79**	**0.000[2 3]**

[1] Change in Mean = Post-test Evaluation - Pre-test Evaluation.
[2] Statistically significannt at $\alpha = 0.05$
[3] Statistically significant changes at the Bonferroni adjusted α=.0036
\+ A positive mean change score represents a change in the favorable direction.
\- A minus mean change score represents a change in the favorable direction.

Table 8 displays t-test of mean change scores between groups for the psychometric measures and nutrition behavior. An increase in cumulative score on the Falls Efficacy Scale suggests an increase in confidence performing basic activities of daily living. The scores can range from 0 to 140. The intervention group showed a mean increase of 5.6 points for falls efficacy, and the delayed intervention group had a mean decrease of 0.5 points. However, this difference in mean change scores between groups was not significant (p=.091).

A decrease in cumulative score on the depression scale is associated with decreased symptoms of depression. Scores for the depression scale can range from 11 to 55. The mean score on the depression scale increased for both groups. The intervention group had an increase in mean change score of 1.17 and the delayed intervention group had an increase in mean change score of 0.95. The difference between groups on the depression indicator was not significant (p=.89).

The locus of control for nutrition scale indicates that subjects with lower scores were more internal with their nutritional control. Scores for this scale can range from 5 to15. The data evaluated for locus of control for nutrition revealed a decrease in mean change scores for both groups. The intervention group mean decreased by 0.17 points and the delayed intervention group mean decreased by 0.47 points. This difference between groups was not statistically significant (p=.50).

A decrease in cumulative score for Nutritious Food Behavior is associated with more nutritious eating habits. Scores for this scale can range from 9 to 27. The intervention group mean decreased by 1.33 points and the delayed intervention group mean increased by 0.84 points. This difference between means was significant at an α=.05 (p= 0.014). However, when the difference between means was compared to the Bonferroni adjusted alpha the results were no longer significant.

In summary, mean change scores between groups were significant for environmental hazards (p=.005), total number of fall risks (p=.000), and nutritious food behavior (p=.014) at an α=.05. When compared to the Bonferroni adjusted α=.0036 only the total number of fall risks was statistically significant. The mean change scores between groups were not significant for fall efficacy, depression, or locus of control for nutrition.

Table 8: T-tests of mean change scores between groups for the psychometric measures and nutrition behavior .

Outcome Variable	Means Change Score for Intervention Group[1]	Means Change Score for Delayed Intervention Group[1]	T St	P-Value
Falls Efficacy Score (+)	5.6	-0.5	1.74	0.091
Depression (-)	1.17	0.95	0.14	0.89
Nutritious Food Behavior (-)	**-1.33**	**0.84**	**2.60**	**0.014[2]**
Locus of Control for Nutrition (-)	-0.17	-0.47	0.68	0.50

[1] Change in Mean = Post-test Evaluation - Pre-test Evaluation.
[2] Statistical significance at $\alpha = 0.05$
There were no statistically significant changes at the Bonferroni adjusted α=.0036
+ A positive mean change score represents a change in the favorable direction.
- A minus mean change score represents a change in the favorable direction.

Simple Regression Results

Simple linear regressions were performed to see if group designation was predictive of changes in the outcome variables. Separate simple regressions were run using each of the physical, environmental hazards, nutrition behavior and psychometric outcome variables as the dependent variable and group designation as the independent variable. Group designation was assigned as a dummy variable. There were no other independent variables added to the regression model because the two groups were found to be similar on all of the demographic and health characteristics measured in this study.

Table 9 displays the outcome variables, β-coefficients, adjusted r-squared, and the p-value for the physical outcomes evaluated in this study. When the change in balance was regressed on group designation 35.4% of the variance was explained. A p-value of 0.000 indicates the intervention group as a significant predictor of positive changes in balance. When the change in bicep endurance was regressed on group designation 29.6% of the variance was explained. Intervention group designation was a significant predictor of increase in bicep endurance (p=.000). When the change in mobility was regressed on group designation 9.1% of the variance was explained. The intervention group was a significant predictor of increased mobility (p=.039). When the change in lower extremity power was regressed on group designation 22.9% of the variance was explained. A p-value of 0.002 indicates the intervention group as a significant predictor of increased lower extremity power.

However, when ankle flexibility was regressed on group designation only 2.0% of the variance was explained for the left ankle and 0% of the variance for the right ankle. The intervention group was not a significant predictor of positive changes in ankle flexibility (left, p=.198; right, p=.397). When the change in upper body flexibility was regressed on group only 2.9% of the variance for the right side was explained and 0% of the variance for the left side. The intervention group was not predictive of positive changes in upper body flexibility (right, p=.159; left, p=.329).

In summary, the intervention group was significantly predictive of changes in balance (0.000), bicep endurance (0.000), mobility (0.039), and lower extremity power (0.002). Group designation, however, was not predictive of changes in either of the flexibility tests for ankle flexion or upper body flexibility.

Table 9: Simple regression of physical outcomes on intervention group designation.

Physical Outcome	Predictor Variables	β Coefficients	Standard Errors	P-Value	Adj. R^2
Balance	Constant	-0.74	0.333	**0.034**	**35.4%**
	Intervention group	2.18	0.479	**0.000[1]**	
Ankle Flexion Right	Constant	-0.11	0.63	0.868	0.0%
	Intervention group	0.77	0.90	0.397	
Left	Constant	-0.53	0.78	0.505	2.0%
	Intervention group	1.47	1.12	0.198	
Upper Body Flexibility Right	Constant	-48.87	51.20	0.346	2.9%
	Intervention group	105.62	73.41	0.159	
Left	Constant	-37.74	27.63	0.181	0.0%
	Intervention group	39.18	39.18	0.329	
Bicep Endurance (dominant)	Constant	-0.74	0.71	**0.304**	**29.6%**
	Intervention group	4.07	1.01	**0.000[1]**	
Mobility	Constant	-0.37	0.21	**0.092**	**9.1%**
	Intervention group	0.65	0.30	**0.039[1]**	
Lower Extremity Power	Constant	-16.35	10.30	**0.121**	**22.9%**
	Intervention group	50.53	14.77	**0.002[1]**	

[1] Statistical significance at $\alpha = 0.05$

Table 10 displays the outcome variables, β-coefficients, adjusted r-squared, and the p-value for environmental risk factors and total number of fall risk factors evaluated in this study. When the change in environmental risk factors was regressed on group designation 19.6% of the variance was explained. When the change in total fall-related risk factors was regressed on group designation 47.4% of the variance was explained. Group designation was significantly predictive of both the environmental changes (p=.004)