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THE EFFECTS OF BALANCE TRAINING ON BALANCE AND FEAR OF FALLING IN OLDER ADULTS

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Abstract

The purposes of this study were to determine (1) the effects of a 6-week balance training intervention on balance and fear of falling in older adults and (2) to evaluate the effects of a 6-week behavioral intervention on adherence to balance exercises and number of falls. Balance was measured using the NeuroCom Balance Master®, the Timed Up and Go, and the Timed Walk tests. Fear of falling was measured using the Falls Efficacy Scale. Twenty-three participants were recruited for this study and were assigned to one of two groups, an intervention group (18) and a control group (5). The balance intervention was provided to the intervention group and were conducted for one hour three times a week for six weeks. After completion of the balance intervention, the intervention group participated in a behavioral intervention, where they were randomly assigned to one of two groups, an intervention group (9) and a control group (9). Participants in the intervention group for the behavioral intervention received encouragement and guidance to continue practicing the balance exercises through emails and phone calls. The control group received no phone calls or emails during this period, but were asked to continue practicing the balance exercises.

A two-way repeated measures ANOVA for time (pre-test, post-test, follow-up) and group (intervention and control) were conducted to evaluate the time and group main effects and time*group interaction for all the outcome variables in order to assess change related to participation in the balance training intervention (pre- to post-test) and the behavioral intervention (post- to follow-up). The results indicated that participation in the balance training intervention significantly improved some balance measures and significantly decreased fear of falling. Participation in the behavioral intervention was

associated with maintenance of balance measures and the fear of falling measure and balance exercise adherence rate when the intervention group was compared to the control group. Future research is advised to further explore the best balance exercises for older adults as well as the best balance measures for older adults.

Chapter I: Introduction

Background

There are declines in physical function, strength, and balance associated with aging, all of which can lead to falls. One in three adults over 65 years experiences a fall each year (Centers for Disease Control and Prevention, 2015). Falls can cause many problems including injury, hospitalization, institutionalization, and/or death. Falls are a major health problem that can be prevented for many individuals. There are several causes and risk factors for falls that can be targeted when developing interventions to prevent falls. The main causes that have been identified are related to the physical environment, gait/balance disorders, dizziness, confusion, postural hypotension, vision problems, and syncope (Rubenstein, 2006). Many individuals experience a loss in muscle strength, diminished postural control, a reduction in the height of stepping, and a decreased reaction time with aging (Rubenstein, 2006), which also can increase risk of falling. Some other causes of falls are foot complications that cause painful feet, sensory problems that make it hard to sense things in the environment (i.e., peripheral neuropathy may make it hard for a person to sense where he/she is stepping), unsafe shoes, medication side effects, noncompliance with medications, and the interaction of medications (National Institutes of Health Senior Health, 2013b). Manchester (1989) found muscle weakness, motor control problems, restricted range of motion, abnormal reflexes, visual/vestibular deficits to central sensory integration, and deficiencies in the central synergy/programming mechanism to be causes of loss of balance in older adults.

Clearly, there are multiple factors that contribute to falls, and most falls do not occur because of a single cause, but rather a combination of factors.

Six out of every 10 falls take place in the home (National Institutes of Health Senior Health, 2013a). Individuals are comfortable in their homes and often do not think about safety when moving around, which puts them at even greater risk (National Institutes of Health Senior Health, 2013a). There are several factors associated with the physical environment of the home that can contribute to falls including: loose rugs on the floor, clutter on the floor or stairs, no handrails on stairs, no grab bars in the bathroom, and poor lighting (National Institutes of Health Senior Health, 2013b). These environmental factors in combination with individual risk factors such as skeletal muscle weakness, balance or gait problems, vision problems, cognitive impairment, mobility limitation, lower functional status, and postural hypotension (Rubenstein, 2006) often interact to increase the risk of falls within the home.

In 2014, there were about 29 million falls, which resulted in about seven million injuries (Centers for Disease Control and Prevention, 2016) in the United States. The total cost of these fall injuries was around $31 billion (Centers for Disease Control and Prevention, 2016). The average cost of a fall injury is around $19,500 for hospital, nursing home, emergency room, and home health care (Learn Not to Fall, 2012). Injuries from falls can range from a minor cut to a severe fracture or a traumatic brain injury. The most common injury from falls are fractures, specifically hip fractures. Other body parts that often are fractured as a result of falls are the spine, forearm, leg, pelvis, hand, and ankle (Centers for Disease Control and Prevention, 2015). Another common type of injury resulting from falls are traumatic brain injuries (Centers for

Disease Control and Prevention, 2015), which can produce long term cognitive, sensory, and motor disabilities. The disabilities associated with these types of injuries make it difficult for an individual to live independently, and increase risk for premature death (Centers for Disease Control and Prevention, 2015).

Individuals also are likely to develop fear of falling after having a fall, which can cause them to limit their level of activity (Centers for Disease Control and Prevention, 2015). Fear of falling occurs in 12% to 65% of older adults who live independently (Legters, 2002). This wide range is for people who had no history of falls and were living independently in the community, were hospitalized, those who had dizziness (Legters, 2002). Fear of falling is a consistent concern about falling that ultimately limits performance of daily activities (Tinetti & Powell, 1993) There are many definitions of fear of falling, so it is difficult to assess. However, it is another factor that can contribute to risk for falls in older adults and should be targeted in fall prevention interventions. It is imperative to find ways to prevent falls from occurring so that older adults are able to live longer, more independent, and happier lives.

Purpose

The purpose of this study was to evaluate the effects of a balance training intervention on balance and fear of falling in older adults. A secondary purpose was to evaluate the effects of a behavioral intervention on adherence to balance exercises and number of falls. The independent variables are time and intervention condition (control or intervention). The dependent variables are balance, fear of falling, and general health status and quality of life.

Research Questions

The research questions for this study include:

RQ1: Will balance improve after participation in a 6-week balance training intervention?

RQ2: Will fear of falling decrease after participation in a 6-week balance training intervention?

RQ3: Will participants in a 6-week behavioral intervention have higher rates of adherence to maintenance of recommended balance exercises than those who do not receive the intervention?

RQ4: Does balance improve from post-test (the end of the balance training intervention) to follow-up assessment?

RQ5: Does fear of falling decrease from post-test to follow-up assessment?

Research Hypotheses

H_R1: Balance will significantly improve from pre-test to post-test after participation in a 6-week balance training intervention.

H_R2: Fear of falling will significantly decrease from pre-test to post-test after participation in a 6-week balance training intervention.

H_R3: Adherence rates will be significantly higher in participants of a 6-week behavioral intervention as compared to those who did not participate in the intervention.

H_R4: Balance measures of participants of a 6-week behavioral intervention will be significantly better at follow-up assessment than those who did not participate in the intervention

H_R5: Fear of falling of participants of a 6-week behavioral intervention will be significantly lower at follow-up assessment than those who did not participate in the intervention.

Significance

One of the main focuses of most fall prevention programming is to increase physical activity levels (aerobic and strength) among at risk individuals. Participation in exercises designed to strengthen the lower body in combination with balance training can help to improve balance (National Institutes of Health Senior Health, 2013c). Zhuang, Huang, Wu, and Zhang (2014) found that older adults who participated in a 12-week exercise intervention experienced improvements in functional mobility and physical performance, which are associated with a reduction in risk of falls. There were also improvements in mobility and balance, which are important when carrying out activities of daily living (Zhuang et al., 2014). This suggests that combining strength and balance training in a fall prevention intervention can be beneficial for older adults. Strengthening exercises and mild weight-bearing exercises can (1) increase or slow down the loss of muscle mass and (2) slow the progression of bone loss and the onset of osteoporosis that may occur with aging. It is important to have strong bones to prevent fractures if someone does fall (National Institutes of Health Senior Health, 2013c). Tai Chi is a type of exercise that has become popular with older adults because it can improve balance, control and strength (National Institutes of Health Senior Health, 2013c). Following participation in a 6-month Tai Chi intervention, improvements were seen in balance, physical performance, and fear of falling in older adults (Li et al., 2005). Tai Chi is an activity that can improve balance and strength, and also decrease fear of falling (Li et al., 2005).

Other ways to prevent falls are to have medications reviewed by a physician, have blood pressure checked on a regular basis, have vision checked regularly, and wear safe footwear (National Institutes of Health Senior Health, 2013c). Making changes to the home to make it a safer environment is sometimes forgotten, but also is a very important target in fall prevention. Some simple changes can be made to decrease fall risk including: improving lighting in every room, removing clutter from the floor, adding grab bars in the shower and next to the toilet, and adding handrails on both sides of the stairway (Centers for Disease Control and Prevention, 2015). It is the interaction between individuals' physical abilities and their exposure to environmental stressors that is a significant risk factor for falls (Lord, Menz, & Sherrington, 2006). Older individuals with fair balance may be the ones at greatest risk of falling from home hazards because they are less likely to take their time when maneuvering around their own homes, which can put them to be at greatest risk (Lord et al., 2006). Likewise, exposure to environmental hazards has been found to contribute more to falls in older vigorous people than among frail older people because they have more exposures to fall hazards (Lord et al., 2006). Making sure that older adults maintain their balance by maintaining lower body strength and keeping their homes safe, will contribute to preventing falls.

Delimitations

Delimitations of this study include:

- All participants were independent living residents within a retirement community, assisted living residents, and nursing home residents.
- All participants were all able to walk, and were able to use a walking aid.
- Both males and females were recruited.
- Exposure to the fall prevention intervention lasted for 6 weeks.
- Some individuals also participated in a 6-week follow-up intervention phase that was designed to facilitate adherence to the fall prevention intervention activities after completion of the supervised program.
- All participants were 65 years of age or older.
- All individuals obtained a medical release before participating.

Limitations

Limitations of this study include:

- The inability to control outside physical activity or other health practices.
- The potential loss of interest in participation in the study, which may result in participant attrition.

Assumptions

Assumptions of this study include:

- Participants will be honest when completing self-report questionnaires.
- Participants will perform the exercises with their best effort and will complete all intervention activities as they are designed.
- All testing equipment will work properly during testing.

Operational Definitions

- **Balance** is the ability to maintain the body's center of mass over its base of support (Watson, 2015). There are two types of balance: static and dynamic.
- **Dynamic Balance** is maintaining the body's center of mass in an upright position while moving.
- **Fear of Falling** can be defined as having low perceived self-efficacy in avoiding falls during activities of daily living (M. Tinetti, Richman, D., & Powell L., 1990).
- **Force plate** is used to measure forces developed during stepping, jumping, and other human-scale actions. The force plate is used with the NeuroCom^{TM} Balance Master, which quantifies the vertical forces exerted through the individuals' feet in order to measure center of gravity and postural control.
- **Medical Outcomes Survey Short Form – 36 (SF-36)** is a survey that measures general health status by yielding an eight-scale profile of scores along with physical and mental health summary measures (Ware, 2000).
- **NeuroCom^{TM} Balance Master** is used to measure static and dynamic balance along with motor responses to positional challenges (NeuroComTM International Inc., 2000). The device uses a dynamic force plate to measure center of gravity and postural control under different conditions.
- **Proprioception** is the awareness of body positions and orientations (Ashton-Miller, 2001). It allows people to know when the foot hits the ground or when the head moves up and down, which help to maintain balance.

- **Somatosensory System** is the part of the sensory system that deals with the conscious perception of touch, pressure, pain, temperature, position, and movement that result from the muscles, joints, and skin. This system influences balance by making the body's musculoskeletal system aware of the spatial and mechanical status in relation to sense of position, movement, and balance.
- **Static Balance** is maintaining the body's center of mass over its base of support while standing still.
- **Vestibular System** involves information about motion, equilibrium, and spatial orientation. This information is provided by the utricle, saccule, and three semicircular canals in each ear. The vestibular system sends messages to the brain and your brain tells your muscles to react to keep you balanced.
- **Visual System** is the part of the central nervous system that gives organisms the ability to process visual detail. It detects and interprets information from the visible light in order to build a depiction of the surrounding environment. The rods and cones send signals to the brain and the brain tells us what we see by creating visual images. These images tell us how close an object is, which helps us to maintain balance. Without the visual system someone might not realize they have to lower a certain amount to take a step down.

Chapter II: Literature Review

The purpose of this study was to evaluate the effects of a balance training intervention on balance and fear of falling in older adults. The purpose of this chapter is to review current literature findings related to balance, the mechanisms that control balance, balance training interventions, strength training interventions, and information related to environmental hazards that increase risk for falls. These were examined in more detail to help understand the efficacy of balance training programs in reducing the risk of falls in older adults.

Balance

Balance can be defined as the ability of the body to maintain the center of gravity within the limits of stability that are determined by the base of support (Yim-Chiplis & Talbot, 2000). The center of gravity (COG) is located in the pelvis, and is the point at which one can compute the gravitational torque for the object as if gravity were acting on that point (Yim-Chiplis & Talbot, 2000). Limits of stability are the sway angles, so if they are exceeded, then the person's center of gravity will be outside of its base of support (Yim-Chiplis & Talbot, 2000). The base of support is the area between the feet and the support surface (Yim-Chiplis & Talbot, 2000). Postural sway is the movement of the center of gravity when the person is standing still. Balance is divided into static balance and dynamic balance. Static balance is the ability to maintain the center of gravity within a base of support during standing or sitting (Yim-Chiplis & Talbot, 2000). Dynamic balance is maintaining an upright posture while the center of gravity and base of support are moving and when the center of gravity is outside of the base of support (Yim-Chiplis & Talbot, 2000). Postural control also involves postural orientation and postural equilibrium (Horak, 2006). Postural orientation (leaning forward while standing and then being able to restore balance back to normal) is the active control of the body alignment with respect to gravity, surface, visual environment, and internal references (Horak, 2006). Postural equilibrium (this provides the body with the stability to stand still) is the coordination of sensorimotor strategies that stabilize the center of mass during self-initiated and externally triggered disturbances in stability (Horak, 2006).

Most young adults maintain balance by using a distal-to-proximal muscle response sequence (Manchester, 1989). This means that the ankles are used more and the legs, thighs, and trunk are also used in order to maintain balance (Manchester, 1989). The muscles used in posterior sway are the tibialis anterior, quadriceps, and the abdominal muscles (Manchester, 1989). The muscles used in anterior sway are the gastrocnemius, biceps femoris, and the paraspinal muscles (Manchester, 1989). There are several lower body and trunk muscles that help individuals to maintain balance or regain their balance if they are to lose balance at some point in time.

Balance is important for functional performance because an individual must be able to maintain balance in order to carry out daily activities such as bathing and getting dressed. People with poor balance can have difficulty doing activities of daily living and they may need help with doing things around the home. Balance needs to be maintained throughout life in order to keep independence to live at home. Being able to do daily activities depends, to some degree, on balance and coordination. Lower body muscle strength also plays an important role in performing daily activities.

Muscle strength, past experience, and size and stability of the base of support play a role in determining the strategies (ankle, hip, stepping) an individual uses to move the center of gravity back to a stable position when losing balance (Yim-Chiplis & Talbot, 2000). In order to maintain balance, an individual needs to have adequate muscle strength and nerve function (Yim-Chiplis & Talbot, 2000). Both muscle strength and nerve function can be improved so that individuals are able to maintain and/or improve balance (Yim-Chiplis & Talbot, 2000). Muscle strength is improved by resistance training, whereas nerve function (recruitment of muscles) is improved through biofeedback and sensory stimulation (Yim-Chiplis & Talbot, 2000). Thus, balance is an ability that individuals can restore after deterioration by retraining the systems involved in balance control. It is important to consider that being able to maintain balance depends on a complex interaction of physiological mechanisms (Horak, 2006). That being said, there is not one single balance test that can measure all systems to assess an individual's balance (Horak, 2006). Some of the main systems involved are the vestibular, proprioceptive, visual, and neuromuscular systems, which will be discussed in the following section.

Mechanisms Involved in Balance

There are several components contributing to the control of balance. These components include vision, vestibular input, proprioception, joint range of motion, postural reflexes, central processing, nerve conduction, muscle strength, and learned strategies (Yim-Chiplis & Talbot, 2000). In addition, other components such as postural sway, hearing, and autonomic systems also influence the control of balance.

The central nervous system maintains balance by monitoring input from the sensory systems and regulating the corresponding voluntary and automatic changes in motor output (Yim-Chiplis & Talbot, 2000).

There are three peripheral sources from which the brain receives information in order to maintain balance (Watson, 2015). These sources are the eyes, muscles and joints, and the vestibular organs, which send information as nerve impulses to the brain. Specific sensory receptors are found in these organs. The sensory receptors in the eyes are the rods and cones. When light hits the rods and cones, they are activated and they send impulses to the brain to provide cues that identify a person's orientation in relation to other objects. The sensory receptors of the skin, muscles, and joints are sensitive to touch or pressure. Any time there is movement of a body part, these receptors send impulses to the brain. Sensory inputs from the neck and ankle are very important for balance because the neck indicates the direction in which the head is turned, whereas, the ankles indicate the body's movement or sway relative to the surface and the quality of the surface. Information from the eyes, muscles and joints, and two sides of the vestibular system are sent to the brain stem. In the brain stem, the information is sorted and integrated with the learned information from the cerebellum and the cerebral cortex. The cerebellum provides information regarding the automatic movements that have been learned over time. The cerebral cortex provides information that has been previously learned by an individual. If these sources conflict with one another, then an individual can become disoriented (Watson, 2015).

The brain stem sends impulses to the muscles that control movement of the eyes, head and neck, trunk, and legs, which allows an individual to maintain balance and have good vision while moving (Watson, 2015). When someone tries to maintain balance the impulses are sent from the sensory receptors to the brain stem and out to the muscles to form a new pathway. Over time, it becomes easier for the impulses to travel the pathway because this pattern has been completed so many times, which is called facilitation. The vestibular system sends motor control signals to the muscles of the eye with the vestibulo-ocular reflex. When the head is not moving, the number of impulses on the right side is equal to the left side. When the head turns right, the number of impulses from the right eye increases, while the number of impulses from the left eye decreases. The interaction of inputs from the two sides controls eye movements and stabilizes the gaze during active head movements and passive head movements (Watson, 2015).

Closed-loop (feed-back) control systems and open-loop (feed-forward) control systems are other components to consider with postural control. Closed-loop control systems operate with sensory feedback, so it works with the visual, vestibular, and somatosensory system in controlling posture (Laughton et al., 2003). The feed-back control is needed for responding fast to any unexpected disturbances or for correcting movement mistakes (Desai, Goodman, Kapadia, Shay, & Szturm, 2010). Open-loop control system operates without sensory feedback, so it works with the commands that control the steady-state activity levels of the postural muscles (Laughton et al., 2003). The feed-forward control is needed to adjust to postural changes in order to maintain balance during voluntary movement (Desai et al., 2010). The open-loop control mechanisms are used over the short-term, whereas the closed-loop control mechanisms are used over the long-term to help maintain the upright position (Laughton et al., 2003). Most individuals are able to select the right motor actions (are able to arrange the environment and can use assistive devices to compensate for instability) at home because they are comfortable with the environment (Desai et al., 2010). Individuals have a harder time selecting the correct motor actions in the outdoor environment because of the unpredicted characteristics (Desai et al., 2010).

Sensory inputs that come from the vestibular, visual, and proprioceptive/somatosensory systems provide important information on balance control (Yim-Chiplis & Talbot, 2000). Proprioception is the awareness of body positions and orientations (Ashton-Miller, 2001). Proprioceptive stimuli from the ankles take priority over opposing visual information in automatic reactions to maintain balance (Yim-Chiplis & Talbot, 2000). For example, children learning to stand are more reliant on vision than those who already know how to stand (Yim-Chiplis & Talbot, 2000). The brain uses sensory inputs to form responses that involve movements of the ankle, knee, leg, and trunk to maintain balance control against forces of gravity (Yim-Chiplis & Talbot, 2000).

Somatosensory inputs provide information about body position and the position of body parts relative to each other and the supporting surface (Hobeika, 1999). These inputs are the dominant sensory information for balance when standing still on a fixed surface (Hobeika, 1999). Human beings rely primarily on the signals from the pressure sensors from the legs and torso in order to maintain balance (Hobeika, 1999). In addition to pressure sensors, it contains visual information regarding the physical environment and the relation of the body to the environment (Hobeika, 1999). Visual inputs play a big role when the support surface is not firm (Hobeika, 1999).

Senses from the somatosensory, visual, and vestibular systems are important when considering an individual's sensory environment, especially when it is changed (Horak, 2006). For instance, when an individual is in a well-lit environment on a firm surface, he/she relies mainly on the somatosensory information (Horak, 2006). If an individual is on an uneven surface, he/she relies more on the visual and vestibular information because they are not relying on the surface inputs as much as they would while standing on a firm surface (Horak, 2006). Being able to re-weight sensory information in response to different sensory contexts is important in order to maintain stability (Horak, 2006) because an individual's balance capability can fluctuate from hour to hour depending on prior experiences and/or attention to the task (Yim-Chiplis & Talbot, 2000).

The vestibular system includes the semicircular canals, which are tubes located in the inner ear, that sense rotational movement of the head and two utricles (fluid filled sacs in the inner ear) and saccules (a bed of sensory cells that are in the inner ear) that sense linear movements of the head and acceleration of gravity (Konrad, Girardi, & Helfert, 1999). The vestibulo-oculomotor reflex includes the semicircular canals that connect to the vestibular nuclei (located in the brainstem), which connects to the oculomotor nuclei (located in the midbrain) (Konrad et al., 1999). The vestibulooculomotor reflex stabilizes images on the retina during movements of the head (Konrad et al., 1999).

The leg muscles do three things for the body while standing upright and walking. They generate support by opposing the downward pull of gravity, generate progression by moving the body forward, and control sideways balance during a step

(Pandy, Lin, & Kim, 2010). The leg muscles that provide vertical acceleration of the center of mass and decrease the forward speed of the body during first half stance are the gluteus maximus, gluteus medius, and vasti lateralis (Pandy et al., 2010). The leg muscles that support the body and move it forward during second half stance are the soleus and gastrocnemius (Pandy et al., 2010). The muscles that contribute to vertical support and forward progression also control the movement of center of mass to the left and right (Pandy et al., 2010).

The control of balance involves many different systems in the body. When one of the systems has a problem, then an individual may have balance dysfunction. It is important to train all of the systems in order to improve and maintain balance, especially in older adults.

Age Related Changes

With aging, there are declines in the somatosensory, vestibular, and visual systems (Manchester, 1989). There also are declines in muscle mass, decreases in type II muscle fibers, decreased muscle strength, and a reduced number of activated motor units (Kirkendall & Garrett, 1998). Older adults also have to activate more muscles during quiet standing compared to young adults in order to maintain their balance (Laughton et al., 2003). All of these can result in balance dysfunction and an increase in falls if muscle mass and muscle strength are not maintained.

Abrahamova and Hlavacka (2008) found an increase in center of foot pressure (CoP) parameters with older age in conditions that had a deficit or a change in sensory information, for example standing on a foam rubber surface. The greatest increases in body sway, CoP displacement, during stance were with no vision or with an alteration to the surface. They found an increase in CoP displacement with vision taken away, but an even greater increase with altered proprioception by standing on a foam surface. The greatest increase in CoP displacement was seen with a combination of absence of vision with altered proprioception. The authors noticed that the increases in CoP displacement started at the age of 60 years, meaning that with older age there is a slight increase of body sway (Abrahamova & Hlavacka, 2008).

Hasselkus and Shambes (1975) found postural sway of older adults to be significantly greater than in young adults. This supports the idea that postural control of the human neuromuscular system declines with aging (Hasselkus & Shambes, 1975). This study examined postural sway under two stance positions: upright and forward lean in both young adult women and older adult women. The authors also concluded that seeing a difference between sway areas in the two age groups proposed the idea that there is a decline in central control of posture with age (Hasselkus & Shambes, 1975).

Fujita (2005) examined body sway changes with age using the Gravicorder in men and women between the ages of 22 and 88 years. The Gravicorder analyzes the tract of center of gravity while standing with eyes open or closed. The three parameters measured were the track length, track density, and track area to look at the changes due to eye closure. The parameters of track length and track area showed highly significant correlations with age, with eyes open and closed, meaning that there was an increase sway with age under both conditions. The parameter of track density showed a negative correlation with age, but only in the eyes open condition, meaning that there was a decrease in efficiency of postural control with age. Using computerized posturography, the authors were able to see an increase in body sway and a less efficient sway control with increasing age (Fujita, 2005).

Rogind, Lykkegaard, Bliddal, and Danneskiold-Samsoe (2003) evaluated postural sway, using the Balance Master Pro®, in an age-stratified sample. They looked at postural control by measuring posturographic parameters. Age was associated with an increase in postural sway. People with greater body weight use different movement strategies when maintaining a vertical position, typically using the joints more distant from the force platform (hip-strategy). The authors concluded that postural sway increases with age, but the amount of ankle strategy used does not depend on age (Rogind et al., 2003).

Baloh, Ying, and Jacobson (2003) conducted a longitudinal study investigating the causes of deterioration of balance and gait in normal older adults over an eight-year time period. There were a total of 59 participants who were examined each year. During the yearly exams, there were several tests conducted: history of falls in the past year, medical history, neurological examination, visual acuity, blood pressure, Tinetti gait and balance test, Mini Mental State Exam (MMSE), Purdue Pegboard motor assessment, and auditory and visual function. They also did pure audiograms and brain MRIs on the day of testing. Referring to the changes in sensory function, all measures showed significant ($p<.05$) age-related declines except for vestibulo-ocular reflex gain at 8.0Hz. Measures of gait and balance from the Tinetti score and neurological exam showed highly significant age-related declines per year. They also found that the number of falls increased significantly with age (Baloh et al., 2003).

Laughton et al. (2003) found that in elderly fallers and non-fallers, the vastus lateralis muscle was significantly more active during quiet-standing compared to young adults ($p<.005$). Elderly non-fallers also had significantly greater co-activation in antagonistic muscle groups compared to young adults ($p<.005$). The older adults in this study activated more muscles while standing quietly, meaning they have difficulty controlling postural balance (Laughton et al., 2003).

People who experience vestibular losses sway more excessively or fall when their visual and somatosensory systems are distorted (Manchester, 1989). People that have vestibular distortions rely on hip motion to control their center of mass, which would be similar to a normal person standing on a narrow beam (Manchester, 1989). People that have peripheral vestibular or somatosensory loss because of neuropathy have a harder time with understanding the sensory information that is being picked up from the feet and being sent to the brain to process. People with neuropathy also have a hard time sensing things so they are not able to make the correct decision when it comes to walking and moving, which makes them have a higher risk of falling compared to people that do not have peripheral or somatosensory loss (Horak, 2006). Older adults tend to sway a lot more, especially when somatosensory inputs and visual inputs are distorted (Manchester, 1989).

It can be concluded that if an older adult has deficits in any of the systems involved in balance control, they are likely to have balance problems. These individuals are more likely to sway, which can cause them to lose balance easier, and put them at risk of falling. With older adults, it is important to target all of the systems when developing interventions so that balance can be improved/maintained.

Adherence in Older Adults

Medical compliance has been defined in many different ways. One of the most commonly used definitions is the extent to which a patient's behavior corresponds with health/medical advice/prescribed treatment (Trostle, 1988). Compliance is clinician centered with the clinician trying to persuade the patient to follow prescribed recommendations (Gould, 2010). Enhancing compliance is important to physicians because it increases the likelihood that the patient will get well or stay well. Patients should have adequate knowledge, motivation, and skills in order to follow the recommendations made by the physician in order to remain compliant. Compliance within the first month of treatment is a strong predictor of long-term compliance for most patient, but generally, it is common to see compliance decrease over time (Miller, 1997).

Adherence is different than compliance in that it is patient-centered rather than centered around the clinician who is trying to make the patient do something. When trying to get a patient to adhere, the clinician is interested in knowing why they are resistant to following recommendations and what information they can provide to the patient to help them. A good definition to explain the difference is that adherence is the extent to which a health behavior reflects the health plan that both the patient and clinician agreed upon together (Gould, 2010). There is no blaming the patient with adherence, which can help to produce more positive outcomes. The goal of this section is to provide information on older adults and adherence rates. While the majority of previous literature is based on medication adherence, this study is an exercise adherence.

Some individual determinants of compliance include gender, availability of transportation, health insurance, socioeconomic status, social support, drug and alcohol use, employment status, stigma, social norms, and cost of treatment. A major determinant of compliance to medical treatments is whether or not someone has social support (Craig, 2015; Goudge, 2011; Stanton, 1987; van Gool, 2006; Zivin, 2008). Having a lack of social support is shown to be a significant issue for many people (Craig, 2015). Some individuals may have financial support, but no emotional support, which may still contribute to noncompliance to the treatment (Craig, 2015). In many cases, people rely on staff from the clinic they attend for treatment to be their support and help to remind them to take their medications (Craig, 2015). When people have greater social support, especially older adults, they are more compliant with medications (Goudge, 2011; Stanton, 1987; van Gool, 2006; Zivin, 2008).

When people feel stigmatized about the condition they have, they are less adherent to treatment (Craig, 2015; Goudge, 2011). These individuals likely hide their condition and take medication in secret (citations). Because they are taking medication in secret, they might run out and not want to get more because they do not want others to know about their condition (Craig, 2015; Goudge, 2011). Individuals may feel like they would be rejected from their community if everyone knew they have a given condition, or they may be asked to leave the community and lose all relationships (Craig, 2015). For some individuals, having a place within a community and relationships is more important than taking medications.

Adherence to medication goes down when the number of prescribed medications is high (Zivin, 2008). This is significant because about 25% of older adults take three or more medications (Zivin, 2008). Reasons why adherence starts to drop with multiple medications is because people do not know the name of medications, do not know the correct dosages, have multiple physicians prescribing medications, and because of drug interactions and side effects (Zivin, 2008). In addition, some people may only take some of their medication (i.e., for depression) when they feel like they need it, but may take other medications for medical illness all the time because they believe they are necessary (Zivin, 2008). It is important that older adults take all medications at the right time and in the right dosage, and all of their physicians need to be aware of all medications they are taking.

In an exercise intervention, individuals were more adherent when they were able to do exercises at home versus taking an exercise class (van Gool, 2006). Exercising at home made individuals feel like they did not have to change their daily routine in order to incorporate a class, and they felt like they had a better sense of control because they were able to choose when to do the exercises (van Gool, 2006). When people have a choice of where they can exercise, they are more likely to be more adherent to an exercise regimen.

In regards to gender, women are more likely to adhere to treatment than men (Herrero, 2015). This is because men tend to be the head of households and work, so they are not able to go to clinics for treatment (Herrero, 2015). Men are also more likely to be using alcohol and drugs which cause them to not adhere to treatment because the alcohol and drugs are more important to them (Herrero, 2015).

Individuals that are in the lower socioeconomic status have lower adherence rates to treatment (Herrero, 2015). These people may not have transportation to get treatment or medication, they may not have the money it costs for treatment, and they may not have the time it takes to be at treatments (Herrero, 2015). These factors all impact those in the lower socioeconomic status and make it very difficult for them to adhere because they either cannot make it to treatment or they cannot afford it. When this is the case, they will stop treatment because they are going to do what they think is best for them.

Some medications make individuals nauseas if they take it on an empty stomach. This can play a role in compliance to medications as well because people will be less compliant if they know this happens. This is especially true in individuals that cannot afford much food (Goudge, 2011). If an individual does not have food they are not going to take the medication because they do not want to feel sick all of the time (Goudge, 2011). Again, it goes back to lack of income and high treatment costs being a barrier that affects compliance to medication for many older adults.

It is hard to determine which social determinant contributes most to non-compliance to treatment, medication, or interventions because there are many of them. All can be a barrier in some way for many individuals, especially older adults. It is important to make sure that barriers are addressed in order to find the best ways to encourage individuals to adhere to prescribed medication, treatment, or interventions.

Balance Training to Reduce Risk of Falling

Balance training is one way to improve balance and decrease the risk of falling among older adults. Granacher, Muehlbauer, Zahner, Gollhofer, and Kressig (2011) conducted a review on balance training programs. Most balance programs use static and dynamic exercises on both stable and unstable surfaces with eyes open and closed. There are no specific guidelines currently for the content, duration, and intensity of exercises in balance training. However, balance training is most beneficial if the base of support changes, the sensory input changes, and the task complexity changes with the training intensity. The American College of Sports Medicine has some preliminary guidelines that involve inclusion of: postures that get progressively harder by reducing the base of support, dynamic movements that disturb the center of gravity, activities that stress the postural muscle groups, and conditions that reduce sensory input. There have been several studies that have shown that both balance training and Tai Chi can improve balance and reduce risk of falling (Granacher et al., 2011).

Another type of more specifically designed balance training is perturbation-based balance training, which is designed to improve control of rapid balance reactions. This type of training allows for strategies for recovery of equilibrium, which plays a major role in preventing falls. In order to successfully recover balance, the center of mass has to remain within the boundaries of the base of support. This can be achieved by different movement strategies (i.e., ankle, hip, and step strategy). The step strategy (used to bring the base of support back in alignment under the center of mass) can provide a larger degree of stabilization, compared to in-place responses where the base of support does not change, when recovering ones balance. Most recovery strategies are not under direct volitional control so it is not possible to train this through voluntary exercises alone. The purpose of perturbation-based balance exercise is to make sure the participant experiences training conditions that match real-life conditions as closely as possible. Studies have shown that after perturbation type training, functional balance, and mobility improve, and there is improvement in step reaction time, which is the time it takes for an individual to react when taking a step, and postural reflex onset latency, which is the time it takes for an individual to get posture back to normal (Granacher et al., 2011).

The last type of balance training for fall prevention programs should include both balance-recovery reactions and multitask balance exercises. Risk of falling increases when shared attention or dual tasks are performed, thus it is important to include this type of training as well. Multitask exercises can improve performance in multitask walking. Granacher et al. (2011) concluded that volume, frequency, and intensity were relatively similar across all types of training; however, specificity of training where exercises match real-life situations is something that could be a major determinant that is responsible for the improved effectiveness of perturbation-based and multitask training versus normal balance training (Granacher et al., 2011).

Tai Chi is another exercise that can be considered as a type of balance training in a broader sense. Li et al. (2005) evaluated the effects of a 6-month Tai Chi intervention for decreasing the number of falls and falls risk in older adults. This study included 256 physically inactive older adults between 70 and 92 years. Participants were randomly assigned to either the Tai Chi group or the stretching control group. They met three times a week for one hour long classes for six months. The primary outcome measure was the number of falls, which were recorded by each participant on a daily calendar. Secondary measures included functional balance, physical performance, and fear of falling. Functional balance was measured with the Berg Balance Scale, the Dynamic Gait Index, the Functional Reach, and a single-leg standing test. The physical performance tests were the 50-foot speed walk and the Timed Up & Go. Fear of falling was measured with the Survey of Activities and Fear of Falling in the Elderly (SAFFE) (Li et al., 2005). There were significantly fewer falls in the Tai Chi group than in the control group at the end of the intervention (p=.007). Seven of the Tai Chi participants reported an injurious fall versus 17 in the control group (p=.03). There was a significant difference in the length of time to the first fall between the Tai Chi group and the control group (p=.007). The Tai Chi group performed significantly better on all of the functional balance measures: Berg Balance Scale (p<.001), Dynamic Gait Index (p<.001), Functional Reach (p<.001), and the single-leg standing test (p<.001). The Tai Chi group also had significant improvements on the physical performance measures: 50-foot speed walk (p<.001) and Up & Go test (p<.001), compared to the control group. For the fear of falling measures, the Tai Chi group reported lower fear of falling scores on the SAFFE than the control group did (p<.001). At the 6-month follow up, the number of people in the Tai Chi group reported significantly lower numbers of falls compared to the control group (p<.001). The balance measures were maintained for both the Tai Chi group and the control group at the follow up. The Tai Chi group sustained better scores than the control group on the 50-foot speed walk, the Up & Go test, and the SAFFE. The authors concluded that Tai Chi is a good way for older adults to maintain and promote health and functional mobility in older adults. Tai Chi can be prescribed for balance training and prescribed for older adults at risk of falling (Li et al., 2005).

An additional type of balance training that can be used is enhanced balance training. Steadman (2003) was interested in assessing the effectiveness of an enhanced balance training intervention on mobility and function in older adults with impaired balance. This study randomized 198 participants over 60 years into an enhanced balance training (EBT) or control group (CT) that received conventional physiotherapy. Participants in the CT group met two times a week for a 45-minute class for four total weeks. The activities the participants in this group completed assisted walking, assessment for mobility aids, stair practice, general bed mobility skills, transfers, and sit to stand. Participants in the EBT group met two times a week for a 45-minute class for four weeks. The participants completed the same exercises as the CT group and extra balance exercises. Some of the balance exercises they did were lateral reaching, retrieving an object from the floor, step-ups, tandem standing, and turning 360º. The following assessments were used: Berg Balance Scale (BBS) to measure balance, number of falls, 10-meter timed walk test (TWT) for mobility, Frenchay Activities Index (FAI) for activities of daily living, Falls Handicap Inventory (FHI) for limitation of social participation, and European quality of life (Euroquol) for quality of life. The Balance Performance Monitor (BPM) was used to objectively measure balance. Results from the study indicated improvements in BBS ($p = 0.0001$), number of falls ($p = 0.0001$), FHI scores ($p = 0.0001$), and FAI ($p = 0.03$) for both groups after completing the intervention. The EBT group also had significant improvements in walking speed ($p = 0.001$) and quality of life measures ($p = 0.04$). Authors concluded that exercise programs can improve balance and mobility. They also suggest that there might be slight difference between enhanced balance training and traditional balance training, but needs further investigation (Steadman, 2003).

Functional balance training can be used as another form of balance training which includes strengthening and balance exercises with functional gait exercises combined. Bulat (2007) evaluated the effectiveness of an 8-week functional balance training on balance in 51 community-dwelling veterans over 70 years. All participants participated in the functional balance classes which met one time a week for eight weeks. during the class, the participants would complete lower body strength exercises, flexibility, coordination, multi-tasking, postural control and gait training. Assessments included the BBS, Limits of Stability (LOS) and modified Clinical Test of Sensory Interaction on Balance (mCTSIB) on the NeuroCom Balance Master®. Participants improved on the BBS ($p < 0.0001$), LOS reaction time ($p = 0.0158$), LOS movement velocity ($p = 0.0192$), Foam- Eyes Open ($p = 0.0262$), and Foam- Eyes Closed ($p = 0.0004$). There were significant changes from pre- to post-test on the BBS ($p < .0001$) and LOS reaction time ($p < .0004$) for participants that attended four-six sessions and those that attended seven-eight sessions. Authors concluded that an 8-week functional balance training intervention improves balance in older adults. It would be important to test the intervention in a trail with falls as the primary outcome rather than balance (Bulat, 2007).

Many of the interventions have been conducted on older adults who are at high risk of falls. There have not been any interventions on older adults who are at the lowest risk of falling. Means (2005) evaluated the short-term effects of an exercise program on older adults with and without a history of falls. This study included 205 older adults over 65 years that were randomized into an exercise group or a control group. The participants in the exercise group completed a 6-week intervention that included active stretching, walking, postural control, and muscle strengthening exercises. The control group participants attended seminars on non-health related topics for older adults. Assessments included the functionally oriented obstacle course (FOC) which consists of 12 simulations, ACTIVITY scores, ROM scores, and STRENGTH scores, fall history and fall-related history. Results from this study indicated significant differences for activity and range of motion ($p = 0.0125$). The intervention group got more active during the intervention and improved in muscle strength, whereas the control group remained the same. There was a significant group by study period time interaction ($p = 0.001$) for obstacle course time. there was also a significant group by study period time intervention ($p = 0.016$) for FOC quality. The intervention group significantly shifted towards no falls after the intervention compared to the control group ($p = 0.002$). Authors concluded that the use of moderate-intensity exercise is effective for reducing or preventing falls in older adults. Recommendations for futures studies included using balance and mobility exercises, encouraging participants to exercise at moderate intensity, and using methods to measure dynamic balance and mobility (Means, 2005).

Balance training has been proven to have beneficial health effects and improvements on balance and mobility. There are many different types of balance training interventions that have been studied, but there is not one that is the best. There are also several different balance measurements, which makes it hard to conclude that all of the interventions worked the same for everyone.

Strength Training to Reduce Risk of Falling

Another way to improve lower body strength and balance is a strength training intervention. Orr, Raymond, and Fiatarone Singh (2008) conducted a systematic literature review of randomized controlled trials to determine the effectiveness of progressive resistance training as an intervention on balance in older adults. The literature review included a total of 29 randomized controlled trials, with most of them including a progressive resistance training group and a control group. The average age of the intervention groups for the studies was between 61-88 years, with the majority of participants being female (70%). The average study duration was 22.7 weeks, with an average training session duration of 58.8 minutes, and averaging 2-3 days a week. Participants completed two to three sets of exercises during each session in all of the studies. Multiple studies had varying intensities at which participants were supposed to perform their exercises during each training session. Progression was accomplished by increasing the training load, although the method by which the training load varied was not consistent. There were several outcome measures, including balance as the main outcome, but also muscle strength, muscle power, functional capacity, mobility, and cognitive function were also measured. Balance measures were characterized as static, dynamic, or functional using computerized dynamic posturography. Using progressive resistance training as a singular intervention was not effective at improving balance. This could be due to the fact that there were multiple outcome measures versus just balance as an outcome measure, where many of the studies were not designed to look at change in balance or were underpowered to find an effect. Many of the studies were not specifically designed to look at the change in balance performance alone. The authors concluded that using progressive resistance training as an isolated intervention may not be the best approach for balance enhancement in older adults (Orr et al., 2008).

Schlicht, Camaione, and Owen (2001) evaluated the effects of lower body strength training on three functional tests that are related to risk of falling. This study had a total of 22 participants between the ages of 61-87 years, with 11 in the experimental group and 11 in the control group. The participants in the experimental group did strength training three days a week for eight weeks. In order to assure that progressive resistance training was utilized throughout the class, 1 repetition maximum (1RM) testing was conducted every two weeks. With the new 1RM value, subjects were encouraged to increase their weight with each exercise every two weeks. Outcome measures included 1RM testing for each exercise to measure muscle strength. Maximal walking speed was measured by timing participants walking across a 25-foot stretch of firm floor. The five repetition sit-to-stand was measured by timing participants while they stood up and sat down as fast as possible five times without using their hands. Balance was measured by recording the greatest time participants could stand on one foot with their eyes open (Schlicht et al., 2001). Results from this study revealed that strength, measured by 1RM, improved for all exercises ($p<.017$). There was a significant between group difference for maximal walking speed ($p<.05$). Sit-to-stand performance was significantly better at mid and post-intervention compared to pre-intervention for the experimental group ($p<.017$). Sit-to-stand performance was significantly better at post-intervention versus mid-intervention for the nonintervention group ($p<.017$). Authors concluded that older adults are capable of completing intense strength training programs and it is safe for them to participate. Strength training programs can improve strength, but it may not be the best method by itself to improve balance of older adults (Schlicht et al., 2001).

Orr et al. (2006) evaluated the dose-response effects of three intensities of power training on balance performance in older adults. A sample of 112 older adults over 60 years were randomly assigned to power training at 20% (LOW), 50% (MED), or 80% (HIGH) of maximal strength or a control (CON) group. Balance was measured on the Chattecx Dynamic Balance System, which can measure static balance and postural sway. There were a total of 18 balance measures from six tests, a total of 12 dynamic balance measures and six static balance measures. Muscle strength was assessed using the digital Keiser pneumatic resistance machines that were fitted with A400 electronics. Participants completed 1RM on five different exercises for muscle strength testing. Muscle power and velocity also were measured at different percentages of 1RM on the same five exercises. Muscle endurance was measured by having the participants do as many consecutive repetitions as possible at 90% 1RM. Body composition, specifically fat-free mass (FFM) was measured using bioelectrical impedance. Participants in the experimental groups performed explosive resistance training at a low load, medium load, or high load. The participants trained twice a week for a total of 10 weeks. The control group did not participate in the training (Orr et al., 2006).

Balance index significantly improved in all groups over time ($p<.001$) and there was a significant group x time interaction ($p=.006$). Total loss of balance significantly improved over time ($p=.003$), with the LOW group showing the best improvement. The greatest improvements in balance were found in the low load power training group. The authors concluded that power training might be beneficial for older adults to target balance, muscle function, and health outcomes related to those physiological domains at the same time (Orr et al., 2006).

Strength training has benefits for older adults, especially because with aging there are declines in strength. However, strength training as an independent intervention may not be the best to improve balance (Orr et al., 2008). Another option would be to incorporate both balance training and strength training into an intervention.

Balance Training and Strength Training to Reduce Risk of Falling

Several studies have been conducted that combined balance training and strength training to improve balance and reduce the risk of falling in older adults. Lord, Ward, Williams, and Strudwick (1995) examined the effects of a 12-month exercise program on balance, reaction time, neuromuscular control, and muscle strength in older women. A sample of 197 women between the ages of 60-85 years were recruited for this study, with 100 participants in the exercise group and 97 participants in the control group. The participants in the exercise group met two times a week for hour-long sessions for four 12-week terms. Each class had four components that all participants in the exercise group participated in: a warm up, conditioning, stretching, and relaxation. The same routine was completed during each component of every class during the intervention. The classes were done in groups in order to encourage social interaction and enjoyment amongst the participants. The warm up included walking in order to raise the heart rate. The conditioning portion included aerobic exercises, strength exercises, and exercises for balance, flexibility, endurance, and hand-eye and foot-eye coordination. During the stretching the participants stretched all of the muscle groups for at least 20 seconds. Muscle strength of the hip flexors and extensors, knee flexors and extensors, and ankle dorsiflexion were measured. Reaction time, neuromuscular control, and postural sway were also measured (Lord et al., 1995). Results from this study showed a significant group by time effect ($p<.001$), meaning the exercise group improved on the test measures, but the control group had little or no change. The exercise group improved significantly on all tests except for the postural sway with eyes open on the floor from baseline to 22-weeks, and all tests except for postural sway with eyes closed on the floor at 12-months. The control group had slight improvements on one test (ankle dorsiflexion strength); otherwise scores were similar over time. People in the control group said the cause of their falls was balance related. People in the exercise group had fewer falls in their own homes and fewer "nonaccidental" falls. The authors concluded that an exercise program can be beneficial for older adults and can improve stability. It was suggested that one-year length of an intervention is needed to see improvements in the exercise group. There still needs to be more research conducted to see if exercise really is an effective way to prevent falls (Lord et al., 1995).

Ramsbottom et al. (2004) evaluated the effects of an exercise program in community dwelling adults over the age of 70 years. The outcomes measured were leg power, static balance, dynamic balance, and functional mobility. There were 16 people that participated in the study, with six in the training group and 10 in the control group. The training group met twice a week for a 24-week program while the control group agreed to continue with normal activities and normal exercise. All participants were tested at baseline, 12 weeks and 24 weeks. The main focus of the exercise class was to strengthen the hip abductors, adductors and flexors and extensors, the shoulder, and the knee flexors and extensors. Classes started with a seated warm up session. During the first four weeks of the class, participants completed exercises on a chair and did simple step coordination's to challenge balance. This was followed by exercises to improve flexibility and mobility. A five-minute cool down was completed at the end of each class. Participants progressed in the class by increasing the resistance and speed of movement. Static balance was measured by looking at postural sway. Dynamic balance was measured using the functional reach test. Leg power was assessed with the Nottingham Power Rig on the quadriceps muscles. Functional mobility was measured with the get-up-and-go test (Ramsbottom et al., 2004). Results from this study revealed that at 12-week measurement (post-intervention) there were no significant differences between the training group and the control group. However, there was a trend for greater improvements in the training group than for the control group. Postural sway was reduced for the training group but not for the control group (p=.05). The training group improved dynamic balance by 23.8% versus 1.5% for the control group, however, there was a non-significant between group difference (p>.05). The training group improved their time on the get-up-and-go test by -6.3% versus -1.0% for the control group (p>.05), but again, the difference was not statistically significant. At 24-week testing, there were significant differences between the training group and the control group for functional reach (p=.01), lower limb power (p<.01), and the get-up-and-go test (p<.05). Overall, there were improvements in lower limb muscle power, dynamic balance, and functional reach in sedentary adults over 70 after a 6-month exercise program (Ramsbottom et al., 2004).

Wolfson et al. (1996) evaluated the effects of balance and/or weight training for 3 months followed by a 6-month low intensity Tai Chi program for maintenance of gains. There were 110 participants over the age of 75 years in this study. There were four intervention groups: Balance (B), Strength (S), Balance + Strength (B+S) and Education Controls (EC). The control group also participated in the Tai Chi training phase. Participants in the balance group met three times a week for 45-minute sessions, with one-on-one instruction. The sessions were divided into platform exercises (center of pressure biofeedback) and non-platform exercises. The participants in the strength group met in groups of two to three for 45-minutes sessions three times a week. Participants started with stretching and then did resistance training with a combination of sandbags, resistive machines, and body weight exercises. The participants in the balance + strength group participated in both 45-minutes balance and 45-minutes strength training three times a week. The educational control group participants continued with their usual activities. All four of the intervention groups met for five 90-minute education sessions on fall prevention and stress management. All four groups also completed the maintenance phase, which included Tai Chi Chuan for 26-weeks. Participants attended group-training sessions once a week for an hour and were also encouraged to practice at home twice a week (Wolfson et al., 1996). All outcome measures were assessed at baseline, after the three-month intervention, and again after the six-month maintenance period. Balance was measured with the computerized posturography platform. In order to measure functional base of support, participants completed two 20-second trials on a stable platform surface. Single stance time was measured while participants performed a semi-tandem, tandem, and single stance for as long as they could. Isokinetic muscle strength was measured using the Cybex 340 isokinetic dynamometer at an angular velocity of 30º s^{-1} at the hip and ankle and 60º s^{-1} at the knee. Flexion and extension were measured at each joint, as well as abduction and adduction at the hip. Usual gait velocity was measured using photoelectric timing devices over an 8-m course. Results from this study showed that there was a significant decrease ($p<.005$) in the number of times participants lost their balance during the sensory organization test for the balance group. There were also significant improvements ($p<.05$) in single stance time for the balance and balance + strength group between baseline and after the three-month intervention. The strength and balance + strength groups had significant improvements in peak joint moment in all joints except for hip abduction and ankle dorsiflexion ($p<.015$). Usual gait velocity significantly decreased for the balance + strength group between baseline and after the three-month intervention compared to all other groups. While the change was small, it is not a positive finding because although it is a decrease in velocity it may be that they went a shorter distance, which could mean they have a hard time with maintaining balance while walking. With the use of weights and balance exercises that were done on firm ground and unstable surfaces could have caused the participants in the balance + strength group to become less confident in their balance. Balance training resulted in significant improvements in all balance outcome measures after the three-month intervention and after the six-month maintenance period. Strength training resulted in increased single stance time after the three-month intervention and after the six-month maintenance; however, it was only statistically significant after the three-month intervention. The authors concluded that relatively healthy older adults are capable of achieving short-term gains in balance and strength from a high-intensity training program. Older adults can also sustain those gains through a low-intensity maintenance program such a participation in Tai Chi (Wolfson et al., 1996).

Zhuang et al. (2014) examined the effects of a 12-week exercise program on physical performance and gait parameters in older community-dwellers. There were 56 participants between the ages of 60 and 80 years old that were randomized into the intervention group or the control group. The physical performance tests that participants completed were the 30-second chair stand test (CS-30), the functional reach test (FR), the timed up and go (TUG) test, and the star excursion balance tests (SEBTs). Maximal isokinetic torque tests were conducted using an isokinetic dynamometer for the flexor and extensors of the knee and ankle. Gait analysis was measured by having participants walk along a 15-m track at a self-preferred speed with reflective markers on the skin. The participants in the intervention group met three times a week for 60-minute exercise classes. The classes consisted of a five minute warm up, followed by 15 minutes of balance exercises, 15 minutes of strength exercises, 15 minutes of Tai Chi Chuan, and ended with 10 minutes of stretching (Zhuang et al., 2014). Results indicated that there was a significant interaction (group x time) effect for the CS-30 test and the TUG test, with an improvement of 15.3% in the CS-30 score ($p<.001$) and a 17.6% improvement on the TUG test ($p<.001$). There was a significant main effect of time on the SEBT ($p=.004$). The intervention group had significant increases of 19.4% and 20.2% of the knee flexor strength and the ankle extensor strength. The intervention group increased gait speed, cadence, and step length significantly at the post-session. Authors concluded that a 12-week combination exercise program improved physical performance and gait parameters in older adults. However, a follow up study is needed to test the long-term effects of this type of program (Zhuang et al., 2014).

A combination of balance and strength training typically results in more benefits for older adults. There are benefits in balance, strength, and physical performance, all of which are important for older adults to maintain their independence. The multicomponent interventions yield better outcomes, so they should be the focus for health practitioners.

Fear of Falling as a Risk of Falling

Fear of falling is a health problem for older adults as it can lead to several issues and is often the start of balance problems for older adults. Fear of falling is a concern about falling that limits a person's ability to do daily activities (Legters, 2002). People that have a history of falls and those that do not have a history of falls report fear of falling (Legters, 2002). Fear of falling leads to poorer health status, increase in restriction of activity, depression and anxiety, and decreased quality of life (Legters, 2002). Fear of falling can result in harmful emotional, psychological, and social changes (Vellas, Wayne, Romero, Baumgartner, & Garry, 1997).

Vellas et al. (1997) conducted a study to identify characteristics of older people who develop fear of falling. They also investigated the association between fear of falling and physical, emotional, psychological, and social well-being over time. This study used 219 older adults over the age of 60 years in a prospective study over two years. All participants completed baseline and follow-up testing of physical and cognitive status as well as a questionnaire to measure self-reported sense of physical, emotional, psychological, and social well-being. Participants also reported all falls that they had during the study period. Results from the study revealed 121 of the 219 participants had a single fall during the two-year study period. Twenty-six of those 121 participants reported fear of falling again because of their reported fall. The remaining 98 participants had multiple falls. Out of those 98 participants, 54 reported no fear of falling, 31 reported fear of falling after one fall, and 13 reported fear of falling after each fall. Fear of falling was significantly associated with the development of balance ($p<.05$) and gait ($p<.001$) problems during follow-up testing. Fear of falling was most common among females and older aged individuals, and was associated with balance and gait problems and poor self-reported physical and cognitive health. There was an inverse correlation between fear of falling and mobility and quality of life and because of this fear of falling might be more of a longer lasting condition rather than just a temporary state that occurs just after a fall. Interventions are needed in order to prevent the consequences of falls and to decrease fear of falling (Vellas et al., 1997).

Tinetti, Mendes de Leion, Doucette, & Baker (1994) evaluated the relationships of fear of falling and fall-related efficacy with measures of basic and instrumental activities of daily living and physical and social functioning in 1,103 older adults over 72 years. Participants reported the number of falls and fall injuries for the previous year. They were also asked if they were afraid of falling and filled out the Falls-Efficacy Scale. Basic and instrumental activities of daily living (ADLs-IADLs), physical activity, and social activity were measured as well. Results from the study showed that the mean fall-related efficacy score was 84.9 (± 20.5). The proportion of participants that reported a decrease in activity because of fear of falling was 24%

among fallers and 15% among nonfallers, which was significantly different between groups ($p<.001$). The correlations between fall-related efficacy and the three functional scores were $r=.34$, $p<.001$ (social activity), $r=.49$, $p<.001$ (physical activity), and $r=.55$, $p=.0001$ (ADL-IADL functioning). Falls efficacy showed an independent, but weak relationship with social activity ($r=.088$, $p<.01$). Fall-efficacy score was highly significantly associated with ADL-IADL ($r=.445$, $p<.0001$) and physical activity ($r=.364$, $p<.001$). The level of confidence in performing daily activities without falling is a correlate of actual performance (Tinetti et al., 1994).

It is important to address fear of falling separately from falls because they are not the same. Including strategies to reduce fear of falling in an intervention can potentially improve quality of life and improve mobility in older adults. If fear of falling can be lowered, then older adults would be more active and not restrict themselves, which puts them at a lower risk of falling. This would also allow older adults to keep their independence, which is the main goal with preventing falls.

Fall Prevention Education

Another component that should be considered when developing fall prevention interventions is education. Education about falls, fall risks, and home safety can be beneficial because many older adults may not know this information. It would be best to add education to an intervention that focuses on exercise in order to increase awareness of strategies than reduce fall risk.

Steinberg, Cartwright, Peel, and Williams (2000) conducted a two-year multi-component intervention that targeted risk factors for reducing the incidence of slips, trips, and falls in older adults. This study recruited 250 participants over the age of 50 years. The participants were randomly assigned to one of four groups. The prevention strategies included education and awareness raising, exercises to improve balance and strength, home safety advice, and medical assessment. The control group (CG) received an oral presentation with a video on home safety and a pamphlet on falls prevention. The second group (CG+EX) received what the control group received plus one-hour exercise classes once a month, with exercise handouts and a video between classes. The third group (CG+EX+HS) got both of those things plus a home safety assessment with financial and practical assistance to make the home modifications. The fourth group (CG+EX+HS+CA) received a clinical assessment and advice on risk factors for falls, plus the other three components. The main outcome measured was the occurrence of an event (slips, trips, and falls). They were monitored using a daily calendar diary. Results from this study revealed that there was a significant reduction in the risk of slipping for groups two, three, and four compared to the control group. Group four (CG+EX+HS+CA) showed the greatest reduction of risk. Groups two (CG+EX), three (CG+EX+HS), and four (CG+EX+HS+CA) also had a significant reduction in the risk of tripping compared to the control group. The intervention strategies resulted in an 18% to 40% reduction in the risk of falling for groups two, three, and four. Most of the reductions were seen with interventions that involved multiple components and not just the education alone. Multi-component interventions can be implemented in communities to reduce the incidence of slips, trips, and falls in community dwellers (Steinberg et al., 2000).

Tennstedt et al. (1998) examined the efficacy of a community-based intervention to reduce fear of falling and associated restrictions in activity levels in older adults. There were 434 people over 60 years who were randomly assigned to the intervention group or the attention control group. The intervention group met twice a week for two hour-long sessions for four total weeks. Education was a major component of this intervention and it was conducted in several different ways including: videos, discussions, role-playing, exercise training, and home assignments. The first sessions focused on changing attitudes and self-efficacy before trying to change the actual behavior. The researchers used a cognitive restricting approach to change attitudes about activity restrictions because of fear of falling. Strength exercises were included in six of the eight sessions. Participants filled out behavior contracts and set their own goals to individualize the program. Outcome measures included fear of falling and assessment of physical, social, and functional activities. Results from the study revealed an increase in intended activity level and a decrease in mobility problems in the intervention group compared to the control group. The intervention group also had reductions in total dysfunction and physical dysfunction. Participants in the intervention group that attended more than five sessions had a significant increase in falls efficacy and perceived ability to manage falls. This intervention was different from others because its main goal was to reduce fear of falling and the associated restrictions in physical and social activity. After the eight-session intervention using a cognitive-behavioral approach, there was an immediate effect on increasing level of intended activity and mobility control. This study emphasizes the importance of addressing fear of falling as an outcome for interventions (Tennstedt et al., 1998).

Education can be provided in many different ways when it is included in a multi-component intervention. It is an easy component to add into an intervention. Not all education has to focus on reduction in falls alone; it can also address fear of falling which is something that is important as well.

Summary

It can be concluded that there are several techniques that are effective in improving balance and reducing the risk of falls for older adults. Without knowing the most important cause of falls for an individual, it is hard to know what factor to target. There is not one best way to reduce the risk of falling, so it is important to include more than one component in an intervention including: education, exercise (balance and strength training), home modifications, and fall recovery strategies.

Chapter III: Methodology

With aging, there are declines in muscle strength, physical function, and balance that can all lead to a higher risk of falls. The purpose of this study was to evaluate the effects of a balance-training program on healthy independent living residents within a retirement community, assisted living residents, and nursing home residents. The following will cover information about the sample, instruments that will be used for testing, research design, procedures for data collection, and data management and analysis procedures.

Sample

Upon approval from the University of Oklahoma Institutional Review Board (IRB), adults over the age of 60 years were recruited. Recruitment of participants was conducted by: posting flyers on campus and in the community, email, word of mouth from subjects, and via a newsletter. The inclusion criteria for this study included:

- Participants were over 60 years,
- Participants were ambulatory (can use the assistance of a cane/walker),
- Participants were able to practice balance exercises on their own,
- All participants obtained a medical release from their physicians,
- Participants were residents of Silver Elm Estates Norman and Southwest Mansions residential communities or agreed to travel to these sites where the interventions were conducted, and
- Participants were able/willing to participate in testing that was conducted in the Functional Performance Laboratory on the University of Oklahoma campus.

The exclusion criteria for this study included:

- Individuals who are under age 60 years,
- Individuals who are not able to walk on their own, and
- Individuals who do not obtain a medical release from their physicians.

The sampling techniques that were used were convenience sampling and snowball sampling. Convenience sampling was used to assure that the group of participants were from two different retirement communities. Snowball sampling was used by having participants tell others about the study. Once the subjects filled out an informed consent form, they were asked to fill out a health history questionnaire. All participants were asked to obtain a signed physician's release form before starting the program. After all participants were consented, they were assigned to either the initial intervention group or a control group. An A priori power calculation were performed for one of the dependent balance variables (the Timed Up & Go Test) based on results from previous research conducted by Suttanon (2012), with a large effect size of 1.09. This indicated that a sample size of 24 is required to provide 80% power at α level of .05 with two different groups. This variable was picked because previous literature used similar variables (Suttanon, 2012).

Instrumentation

There was a standard oral script used to give instructions for all tests, to all participants at all data collection points. The dependent variables that were measured in this study include balance, fear of falling, and health status. These variables were measured using the following instruments/procedures.

NeuroCom™ Balance Master. The NeuroCom™ Balance Master measures static balance and motor responses to positional challenges (NeuroComTM International Inc., 2000). It evaluates balance with a force plate that is located in a platform base. Participants stand on the platform where force sensors that are positioned under the force plate will measure the vertical forces that are exerted by the participants' feet/body weight. There are five NeuroCom™ tests that will be used for this study: the modified clinical test for the sensory interaction on balance (mCTSIB), sit-to-stand (STS), tandem walk (TaW), step/quick turn (SQT), and step up and over (SUO).

- The modified clinical test for the sensory interaction on balance (mCTSIB) measures postural sway velocity with the participant standing quietly on a firm surface and then on a foam surface with the eyes closed (EC). The purpose of this test is to identify sway abnormalities that usually result from abnormalities in the sensory systems (somatosensory, visual, and vestibular) that contribute to postural control. The mean sway velocity measured in degrees per second will be recorded for the mCTSIB.
- The sit-to-stand (STS) test measures sway characteristics while the participant rises from a seated position to a standing position. This test will assess sway abnormalities that usually result from lower body and trunk strength and sensory loss (i.e., neurological damage caused by a lesion to a single tract in the spinal cord that results in loss of fine touch and proprioception without loss of pain). The mean sway velocity measured in degrees per second will be recorded for the STS test.

- The step quick/turn (SQT) test measures movement characteristics when the participant takes two steps forward, turns 180 degrees quickly, and steps back to the starting location. During this test, direction change and stepping must be tightly coordinated, because head rotation produces changing visual and vestibular inputs. This test will assess sway abnormalities that usually are related to sensory loss, ankle weakness, and sensory (visual/vestibular) problems (NeuroCom^{TM} International Inc., 2000). The mean turn sway measured in degrees and the mean turn time measured in seconds will be recorded for the SQT test.
- The tandem walk (TaW) test measures characteristics of gait as the participant "walks a tightrope" (heel to toe) from one end of the forceplate to another (NeuroCom^{TM} International Inc., 2000). The endpoint sway velocity measured in degrees per second will be recorded for the TW test.
- The step up and over (SUO) test measures movement characteristics when the participant steps up onto a curb with one foot, lifts the other foot over the curb and down onto the floor, and then steps down with the foot that was placed on the curb. This test will assess strength, balance and coordination (NeuroCom^{TM} International Inc., 2000). The mean end sway measured in degrees will be recorded for the SUO test.

Liston (1996) used participants with hemiparesis to test the reliability and validity of the NeuroCom Balance Master®. They found that the tests that required participants to shift their center of gravity to highlighted targets (LOS) were highly reliable in terms of movement time (ICC=.88) and movement path (ICC=.84). The dynamic NeuroCom Balance Master® variables have been correlated with the Berg Balance Scale. The weight shift left to right at 3-second (r=-.51, p<.025), and 2-second pacing (r=-.48, p<.035), weight shift forwards and backwards at 3-second (r=-.67, p<.002), and 2-second pacing (r=-.53, p<.016); limits of stability movement time (r=-.55, p<.012) and path sway (r=-.61, p<.005). The static Balance Master variables were not correlated with the functional balance tests. The NeuroCom^{TM} is a reliable and valid tool for measuring balance (Liston, 1996).

Timed Up & Go Test (TUG). The Timed Up & Go Test measures the amount of time it takes a subject to stand up from a chair, walk 3 meters, turn, walk back to the chair, and sit down (Steffen, Hacker, & Mollinger, 2002). The TUG is a short test of basic mobility skills (Steffen et al., 2002), which is a quick and easy test to administer and is most often used in the older adult population. Inter-rater reliability measured with an ICC (3,3) was *r*=.98, making it a reliable measure (Shumway-Cook, 2000). Bennie et al. (2003) found the TUG to be significantly correlated with the BBS (*r*=.47, p=0.04). The TUG was also correlated with the functional reach test, but the correlation was not significant (*r*=.56, p=0.06) (Bennie, 2003). Based on these results, it can be concluded that the TUG is a reliable and valid measure of balance.

Timed Walk Test (TiW). The timed walk test measures the amount of time it takes for a participant to walk on a path that is the distance from sidewalk to sidewalk on a two lane road, which was 38 feet.

Falls Efficacy Scale (FES). The Falls Efficacy Scale measures a person's confidence in performing several activities of daily living without falling (Yardley et al., 2005). The FES includes a total of 10 items, with a possible score of 10-100 (Tinetti, Richman, & Powell, 1990). Subjects are asked to rate their confidence in performing the daily activities, using a 10-point continuum. The FES score is the sum of the scores for each item. Having a higher score means that the person has a lower confidence or efficacy in maintaining balance (Tinetti, Richman, & Powell, 1990). Tinetti, Richman, & Powell. (1990) found that the FES has a good test-retest reliability (r=.71). Hotchkiss (2004) found that the FES was highly correlated with the Activities Specific Balance Confidence Scale (r=.86) and was moderately correlated with the Survey and Fear of Falling in the Elderly (r=.67). The FES was found to be the best predictor of people who restrict their activity, with scores explaining 28% of the variance (Hotchkiss, 2004). These findings indicate that the FES is a reliable and valid measure for fear of falling.

Medical Outcomes Survey. The 36-Item Short Form (SF-36) survey will be used to measure general health status as perceived by participants. The survey yields an eight-scale profile of scores along with physical and mental health summary measures (Ware, 2000). The eight scales include: physical functioning (10), role-physical (4), bodily pain (3), general health (5), vitality (4), social functioning (2), role-emotional (3), and mental health (2) (Ware, 2000). Reliability of the eight scales and two summary measures have been good (r>.80), while the reliability for the physical and mental health scores are even better (r>.90) (Ware, 2000). The mental health, role-emotional, and social functioning scales are the most valid scales for mental health measures (Ware, 2000). The physical functioning, role-physical, and bodily pain scales are the most valid scales for physical health (Ware, 2000). The SF-36 scales correlate well (r>.40) with most general health concepts and with the frequency and severity of specific symptoms and problems (Ware, 2000). These values indicate that the SF-36 is a reliable and valid tool to measure self-reported general health status.

Exercise Adherence. Exercise adherence was measured as the total number of minutes that participants carried out balance exercises at home. It was measured by having participants fill out a log each week that tracked the number of exercises done each time and the amount of time spent doing the exercises for six weeks.

Falls. Participants logged if they had a fall during the 6-week adherence intervention. The participants also recorded the factors they think contributed to the fall.

Research Design

The research design was a within subjects repeated measures design. This design allowed the researcher to answer the research questions because participants were assigned to a control (balance CON) or intervention (balance INT) condition for the duration of the first six-week intervention. During this intervention, participants in the balance training intervention went to class three times a week for a 60-minute fall prevention class. During each class participants were provided with information related to fall prevention using brochures that were created by the principle investigator and practiced exercises that were designed to impact the factors that control balance based on previous literature of balance interventions. The participants in the control group were asked to maintain normal activity during the first six-week intervention. All dependent variables were measured at pre-intervention (W0), after completion of the first intervention phase (W7-9), and after completion of a second 6-week adherence intervention/follow- up period (W16-18). Prior to pre-testing (W0), participants were asked to maintain normal lifestyle patterns until all baseline testing was completed. Following the first intervention period, the balance control group was given the option to participate in the 6-week fall prevention intervention. During the same 6-week period, the individuals who completed the first wave of the intervention were randomized into two groups and asked to continue the exercises they had been taught during the balance training program. One group (adherence INT) was provided with additional information and encouragement to continue to practice the fall prevention exercises that were covered during the intervention period and the second group (adherence control) received no additional information or encouragement to continue practice of the intervention exercises. As noted above, measurement of all dependent variables was conducted again at the end of the second 6-week intervention period. This design allowed for the testing of two different interventions: (1) the fall prevention intervention that was completed by members of both groups during two different intervention periods and (2) a behavioral intervention that was designed to motivate continued practice of fall prevention exercises after completion of the structured, supervised intervention that was completed by the first intervention group. This design allowed for the following:

- Comparison of Balance INT1 to Balance CON1 after week 6 (2X2 repeated measures ANOVA) to evaluate the efficacy of the falls prevention program in changing DVs.

- Comparison of Adherence INT1+support to Adherence INT1+no support after completion of the adherence intervention at week 12 (dependent t-test) to evaluate the efficacy of the adherence intervention.
- Comparison of Balance INT1 + Adherence INT2 pre- to post-falls prevention intervention to evaluate the efficacy of the intervention across group.

Threats to Internal and External Validity

Internal validity relates to whether the experimental treatment (independent variable) results in a true change in designated outcomes (dependent variables). External validity relates to whether the experimental effect can be generalized to other populations, settings, treatment variables, and measurement variables.

Potential threats to internal validity for this study were:

- History – Participants may be exposed to conditions that affect balance during the course of the intervention that are not controlled by the study design.
- Maturation – There is a possibility that there may a natural decline in balance over the time period of the intervention, particularly in older participants
- Experimental mortality - the dropout rate cannot be controlled since participation is voluntary.
- Testing effect - the pre-test may affect the post-test because the participants may learn the test and figure out how to improve performance.

Potential threats to external validity were:

- Interaction effects of selection biases and the experimental treatment – results can be generalized only to other older adult populations

- Reactive effects of experimental arrangements - participants know they are participating in a study and their performance may be affected by that knowledge.

Data Collection Procedures

Evaluation Procedures

The principle investigator collected all data. Prior to baseline testing, the primary investigator developed a balance training program that included both exercise and knowledge components. Testing occurred at baseline (W0), during W7-9 (after completion of the 6-week intervention period), and during W16-18 (after completion of the second 6-week intervention period). Each testing session lasted about an hour to an hour and a half to complete all tests. Participants filled out the informed consent first, then a health history questionnaire. Following the health history, participants filled out the FES and the SF-36 survey. After filling out the surveys, participants completed performance-based tests in a randomized order for each testing period. The following were the performance-based tests that were completed:

- NeuroCom™ Balance Master tests,
- Timed Up & Go, and
- Timed walk test.

Participants were given breaks between tests in order to minimize fatigue, which could affect performance.

Intervention Procedures

The balance training program included several exercises designed to improve balance and strength by improving vestibular, visual, and neuromuscular function. Exercises for the program included:

- Calf raises (both feet and one foot),
- Standing with feet together (eyes open and eyes closed),
- Standing on one foot (eyes open and eyes closed),
- Sit-to-stand,
- Tandem stand (eyes open and eyes closed),
- Hip raise (balance on one leg, lift hip upward, then repeat on other leg),
- Hip extension (balance on one leg, extend hip behind body, then repeat on other leg),
- Knee bend (balance on one leg, bend knee, then repeat on other leg),
- Tandem walking (heel-to-toe),
- Turning 360°,
- Walking on toes,
- Walking on heels,
- Walking sideways,
- Walking backwards,
- Standing with feet together on foam pad (eyes open and eyes closed),
- Standing on one foot on foam pad.

All classes started with a 10-minute warm up period and ended with a 10-minute cool down period. The warm up period was done to bring participants heart rates up and to warm up the muscles. During the cool down period, participants stretched all major muscle groups. Each stretch was held for 30 seconds and completed twice. All exercises were done three times for at least 30 seconds on each exercise, for some exercises the time increased as the participants progressed. Exercises were modified to meet individual needs. In order to increase safety of the exercise environment, a chair was placed near each participant so that it could be used to stabilize the body during movement. Participants started practicing exercises on a firm surface and then progressed to practicing certain exercises on a pliable surface such as foam. Initially, exercises were practiced with eyes open and progressed to completing the exercises with eyes closed. Attendance was collected from the participants based on if they checked off that they were in class for the day.

The education component contained a new topic each week that was discussed one day in the week. The topics were discussed at the end of class, while the participants were cooling down. There were handouts over each topic for the participants to take home. Information was verbally said to the participants by the primary investigator. The six topics included:

- Fall prevention importance,
- Risks and causes of falls,
- How to get up from a fall,
- Home safety importance,
- Home modifications that can be made, and
- Other exercises that can help prevent falls.

While the discussion was brief in each class, the participants still had a handout to take home that explained everything over the topic.

Adherence was measured only during the follow-up 6-week intervention (post-test to follow-up) and was used to determine the efficacy of the behavioral intervention implemented during the second phase. The intervention components included:

- One email each week, a biweekly phone call, and a weekly text message to those that have a cell phone. The email, text message, and phone call provided reminders (cues to action), inspirational messages (motivation), and verbal reinforcements (self-efficacy). The phone call was used to keep track of adherence and address any concerns the participants might have,
- a weekly exercise adherence log that tracked how many exercises and how much time was spent doing the exercises, and
- a weekly falls log in which they recorded the number of falls and the factors that they think contributed to the fall.

Process Evaluation

To ensure that the program was conducted as planned, information was gathered and recorded continuously that was related to the participants and their performance in the program. The following was tracked during the study: response rate to weekly emails, response rate to biweekly phone calls, response rate to weekly text messages, average time (minutes) per week spent doing balance exercises, and submission rates of weekly logs.

Data Management and Analysis

The independent variables are time (pre-intervention, post-intervention, and follow-up) and conditions (control vs intervention). The dependent variables are balance, fear of falling, health status, exercise adherence, and falls. Data were analyzed using SPSS Statistics version 19.0. A 2 X 2 ANOVA with repeated measures was conducted for all dependent variables to determine the effect of balance training on all dependent variables. The level of significance was set at $\alpha = .05$ for all analyses.

Chapter IV: Results and Discussion

The purposes of this study were to evaluate the effectiveness of (1) a 6-week balance training intervention on balance and fear of falling and (2) a 6-week behavioral intervention program designed to increase adherence to balance exercises in older adults, aged 70-90 years. The variables of interest were measured using the NeuroCom Balance Master®, the Falls Efficacy Scale, and a fear of falling and health survey. Study results are presented in the following order:

- Demographic characteristics of participants
- Description of outcome variables used in the study
- Descriptive statistics for all outcome variables
- Data analysis procedures
- Results for research questions
- Discussion of results

Participant characteristics are reported as means and standard deviations for continuous variables and frequencies and percentages for categorical variables for the two groups. The balance training intervention group is represented as BAL INT and the balance control group is represented as BAL CON in all tables. Means and standard deviations of all the variables measured at pre-test, post-test, and follow-up are reported for all the variables in the intervention and control groups. The average number of exercise sessions attended during the balance training intervention for the BAL INT group was 17 sessions.

Demographic Characteristics of Participants

Demographic characteristics for all participants are reported in Table 1. Twenty-three participants were recruited for this study, with 18 in the balance intervention group and five in the balance control group. Almost all participants were white (87%) with most of them widowed (65%). All participants were retired (100%). This sample was well educated with 74% had a college education or better.

When demographics were broken down by group, there were 13 females (72%) and five males (27%) in the balance intervention group and four females (80%) and one male (20%) in the balance control group. There were 13 widowed (72%) and five married (27%) individuals in the balance intervention group and two married (40%), two widowed (40%), and one divorced (20%) individuals in the balance control group. There were 15 Caucasian (83%), two Hispanic (11%), and a Japanese (5%) participant in the balance intervention group and all were Caucasian in the balance control group. In the balance intervention group, four had a high school degree (22%), five had a college degree (27%), and nine had a graduate degree (50%), whereas in the balance control group one had a high school degree (20%), three had a college degree (60%), and one had a GED (20%). For income, there were five that did not know (27%), seven with an income of $20,000-40,000 (39%), two with an income of $40,000-60,000 (11%), one with an income of $60,000-80,000 (5%), and three with an income of >$80,000 (16%) in the balance intervention group. The balance control group had one that did not know her/his income (20%), one with an income of $10,000-20,000 (20%), one with an income of $20,000-40,000 (20%), and two with an income of $40,000-60,000 (40%).

Table 1. Demographic Characteristics of the Total Sample (N=23)

Characteristics and Category	n	%
Gender		
Female	17	74%
Male	6	26%
Ethnicity		
Caucasian	20	87%
Hispanic	2	9%
Japanese	1	4%
Marital Status		
Widowed	15	65%
Married	7	30%
Divorced	1	4%
Education		
Graduate	9	39%
College	8	35%
High School	5	22%
GED	1	4%
Occupation		
Retired	23	100%
Income		
Over $80,000	3	26%
$60,000-$80,000	1	4%
$40,000-$60,000	4	17%
$20,000-$40,000	8	35%
$10,000-$20,000	1	4%
Don't know	6	26%

Description of All Outcome Variables

All outcome variables were measured using the NeuroCom Balance Master® tests, the Falls Efficacy Scale, functional performance measures, and surveys. These are all listed in Table 2 (NeuroCom Balance Master® Variables), Table 3 (Fear of Falling Variable), Table 4 (Functional Balance Variables), and Table 5 (Health Status - SF-36 Medical Outcomes Survey Variables). All tables include variable names, abbreviations, and range of scores for each variable. A group effect indicates that the mean of times (pre- and post- intervention) are different for both groups. A time effect indicates the mean of the groups at pre- and post- intervention were different. The group effect and time effect are reported throughout the results, but are not significant for this study because it does not show the effects from the intervention.

Table 2. Description of Balance Variables – NeuroCom Balance Master® Protocols.

Test Name and Abbreviation	Variable Measured	Range of Scores
Modified Clinical Test for the Sensory Interaction on Balance (mCTSIB)-Firm (FI) & Foam (FO) Surfaces	Mean Sway Velocity (degrees/sec)	0-10 - low scores indicate less postural sway
Sit-to-Stand (STS)	Mean Sway Velocity (degrees/sec)	0-20 - low scores indicate less postural sway
Tandem Walk (Steinberg et al.)	Mean Sway Velocity (degrees/sec)	0-20 - low scores indicate less postural sway
Step/Quick Turn Sway (SQT)	Mean Turn Sway (degrees/sec)	0-80 - low scores indicate less postural sway
Step/Quick Turn Time (SQTTT)	Turn Time	0-20 - low scores indicate less postural sway
Step Up and Over (SUO)	Mean Impact Index (% of body weight)	0-80 - low scores indicate less postural sway

Table 3. Description of Fear of Falling Variable.

Variable Measured	Abbreviation	Range of Scores
Falls Efficacy Scale	FES	10-100 - low scores indicate less fear of falling

Table 4. Description of Functional Balance Variables.

Variable Measured	Abbreviations	Range of Scores
Timed Up & Go	TUG	0-20 - low scores indicate better function
Timed Walk	TW	0-25 - low scores indicate better function

Table 5. Description of Health Status (SF-36 Medical Outcomes Survey) Variables.

Variable Measured	**Abbreviations**	**Range of Scores**
Physical Functioning	PF	0-100 - high scores indicate better health status
Role Limitations Due to Physical Health	RLph	0-100 - high scores indicate better health status
Role Limitations Due to Emotional Problems	RLep	0-100 - high scores indicate better health status
Energy/Fatigue	E	0-100 - high scores indicate better health status
Emotional Well-Being	EW	0-100 - high scores indicate better health status
Social Functioning	SF	0-100 - high scores indicate better health status
Pain	P	0-100 - high scores indicate better health status
General Health	GH	0-100 - high scores indicate better health status

Descriptive Statistics for All Outcome Variables

Tables 6-18 present the descriptive statistics for pre-test, post-test, and follow-up test for outcome variables related to participation in the balance intervention and behavioral intervention (pre-test to follow-up) by sample and by groups (intervention and control). Each of the NeuroCom outcome variables was measured three times at each measurement point. After reviewing the data to determine if there was a consistent pattern of improvement after the first trial (indicating a practice effect), there was no evidence that there was a practice effect. Because of this, the average of the three trials was used to determine the means and standard deviations for all NeuroCom Balance Master® measures.

Table 6. Descriptive Statistics for Health Status Variables by Total Sample and by Groups.

Variables	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
PF	BAL INT	18	60.3±20.5	65.5±20.1	61.7±22.5
	BAL CON	5	46.0±17.8	53.0±16.8	
RLph	BAL INT	17	62.9±35.6	84.7±25.9	72.9±32.8
	BAL CON	5	30.0±11.2	60.0±45.4	
RLep	BAL INT	17	74.0±38.9	81.5±34.7	77.8±41.0
	BAL CON	5	60.0±54.8	60.0±43.5	
E	BAL INT	18	66.1±16.3	64.4±15.4	66.3±18.5
	BAL CON	5	56.0±21.6	60.0±14.6	
EW	BAL INT	18	78.6±14.2	81.6±16.5	78.7±17.3
	BAL CON	5	77.4±6.8	80.0±13.9	
SF	BAL INT	18	77.9±24.2	86.1±18.1	84.4±19.3
	BAL CON	5	75.0±30.6	75.0±23.4	
P	BAL INT	18	76.7±20.7	73.9±16.5	74.6±21.2
	BAL CON	5	60.0±29.3	76.5±18.2	
GH	BAL INT	18	65.2±18.3	73.3±11.4	70.0±12.4
	BAL CON	5	58.0±18.2	53.0±22.5	

Abbreviation: INT-Intervention group; CON-Control group

Descriptive statistics are reported as means and standard deviations. A decrease in scores across time for the Falls Efficacy Scale reflect a decrease in fear of falling. An increase in scores across time for the SF-36 Medical Outcomes Survey indicate an improvement in health status based on the different scales.

Table 7. Independent t-Tests for Baseline Values for Study Dependent Variables.

Variable	Group	n	t (df)	p-value (1-tailed)
FES	INT	18	-1.5 (21)	0.150
	CON	5		
PF	INT	18	1.4 (21)	0.086
	CON	5		
RLph	INT	18	2.0 (20)	0.058
	CON	5		
RLep	INT	18	0.7 (20)	0.308
	CON	5		
E	INT	18	1.1 (21)	0.133
	CON	5		
EW	INT	18	0.2 (21)	0.432
	CON	5		
SF	INT	18	0.2 (21)	0.412
	CON	5		
P	INT	18	1.5 (21)	0.079
	CON	5		
GH	INT	18	0.8 (21)	0.223
	CON	5		
TUG	INT	18	-1.3 (21)	0.104
	CON	5		
TiW	INT	18	0.3 (21)	0.398
	CON	5		
FIEO	INT	18	-0.9 (21)	0.928
	CON	5		
FIEC	INT	18	-0.8 (21)	0.222
	CON	5		
FOEO	INT	18	-0.2 (21)	0.426
	CON	5		
FOEC	INT	18	0.8 (20)	0.209
	CON	5		
STS	INT	18	0.7 (21)	0.262
	CON	5		
TaW	INT	18	-1.9 (21)	0.031*
	CON	5		
SQT	INT	18	-3.1 (21)	0.003*
	CON	5		
SQTTT	INT	18	-2.4 (21)	0.012*
	CON	5		
SUO1	INT	18	0.5 (21)	0.299
	CON	5		
SUO2	INT	18	0.4 (21)	0.358
	CON	5		

Abbreviation: INT-Intervention Group; CON-Control Group

A decrease in time on the functional performance tests (Timed Up & Go and the Timed Walk) reflects an improvement in function and balance. Decreases in measures of sway over time indicate improvement in balance. Plots of overall time effect for all variables by group can be found in Figures 1-17.

Data were compared between groups at baseline using independent *t*-tests to ensure equality and are listed in Table 7. All baseline variables were equal between groups except for Tandem Walk sway ($p = 0.031$), Step Quick Turn sway ($p = 0.003$), and Step Quick Turn time ($p = 0.012$). The tandem walk indicated that the control group performed better (lower mean sway) than the intervention group. The step quick turn to the right and to the left (averaged to yield a single SQT performance variable) indicated that the control group performed worse (had a greater turn sway) than the intervention group. The step quick turn time to the right and to the left indicated that the control group performed worse (higher turn time) than the intervention group.

Data Analysis Procedures

A two-way repeated measures ANOVA (pre-test and post-test) was used to assess the between group differences in all outcome variables over time for assessing changes associated with participation in the balance intervention immediately after the program. Another two-way repeated measures ANOVA (post-test and follow-up) was used to assess changes related to participation in the behavioral intervention at 6-weeks follow-up. To assess adherence to the balance exercises during the follow-up period (post-test to follow-up), the total number of weeks each participant reached 3 days/week were calculated. In addition, the average minutes of balance exercises/week were calculated. Also, the total number of falls each participant had over the 6-week behavioral intervention was calculated.

Results for Research Questions

This study attempted to answer five research questions. The results for each research question are presented in this section.

Balance:

RQ1: Will balance improve after participation in a 6-week balance training intervention?

A summary of the two-way ANOVA for modified clinical test for the sensory interaction on balance (mCTSIB) balance measures by group (intervention vs. control) and time (pre- and post-intervention) is provided in Table 9 and descriptive statistics are provided in Table 8.

Table 8. Descriptive Statistics for the NeuroCom Static Balance Variables by Total Sample and by Groups.

Variables	Group	N	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
FIEO*	BAL INT	18	0.39±0.16	0.31±0.13	0.38±0.18
	BAL CON	5	0.40±0.28	0.35±0.13	
FIEC*	BAL INT	18	0.44±0.26	0.43±0.32	0.38±0.23
	BAL CON	5	0.56±0.41	0.75±0.74	
FOEO*	BAL INT	18	1.15±0.31	1.34±0.54	1.19±0.36
	BAL CON	5	1.18±0.34	1.01±0.33	
FOEC*	BAL INT	18	1.79±0.57	2.34±0.76	1.75±0.74
	BAL CON	5	1.55±0.33	1.67±0.54	

Abbreviation: FI-Firm; FO-Foam; EO-Eyes Open; EC-Eyes Closed; INT- Intervention; CON- Control
*measured in degrees/sec sway

To evaluate mCTSIB balance, several measures were used: firm surface with eyes open (FIEO), firm surface with eyes closed (FIEC), foam surface with eyes open (FOEO), and foam surface with eyes closed (FOEC). There was no significant time effect ($p = 0.158$), time by group interaction ($p = 0.742$), or group effect ($p = 0.732$) for the balance measure of standing on a firm surface with the eyes open. There was no significant time effect ($p = 0.160$), time by group interaction ($p = 0.098$), or group effect ($p = 0.226$) for the balance measure of standing on a firm surface with the eyes closed.

Table 9. Two Way ANOVA for the NeuroCom Static Balance Variables by Group (intervention vs. control) and Time (pre- and post-intervention).

Variables	Source	df	SS	MS	F	p-value	Power	Effect Size
FIEO	Between Subjects							
	Group	1	0.004	0.004	0.121	0.732	0.063	0.006
	Error	21	0.746	0.036	-	-	-	-
	Within Subjects							
	Time	1	0.033	0.033	2.142	0.158	0.287	0.093
	Time*BalGroup	1	0.002	0.002	0.11	0.742	0.062	0.005
	Error	21	0.321	0.015	-	-	-	-
FIEC	Between Subjects							
	Group	1	0.382	0.382	1.558	0.226	0.222	0.069
	Error	21	5.152	0.245	-	-	-	-
	Within Subjects							
	Time	1	0.060	0.060	2.119	0.160	0.285	0.092
	Time*BalGroup	1	0.085	0.085	3.002	0.098	0.380	0.125
	Error	21	0.596	0.028	-	-	-	-
FOEO	Between Subjects							
	Group	1	0.177	0.177	0.761	0.393	0.132	0.035
	Error	21	4.880	0.232	-	-	-	-
	Within Subjects							
	Time	1	0.000	0.000	0.003	0.958	0.050	0.000
	Time*BalGroup	1	0.256	0.256	1.982	0.174	0.269	0.086
	Error	21	2.713	0.129	-	-	-	-
FOEC	Between Subjects							
	Group	1	1.378	1.378	2.157	0.157	0.288	0.097
	Error	20	12.781	0.639	-	-	-	-
	Within Subjects							
	Time	1	0.698	0.698	3.858	0.064	0.464	0.162
	Time*BalGroup	1	0.293	0.293	1.620	0.218	0.228	0.075
	Error	20	3.621	0.181	-	-	-	-

Figure 1. Overall Time Effect for Firm Eyes Open (FIEO) by Group.

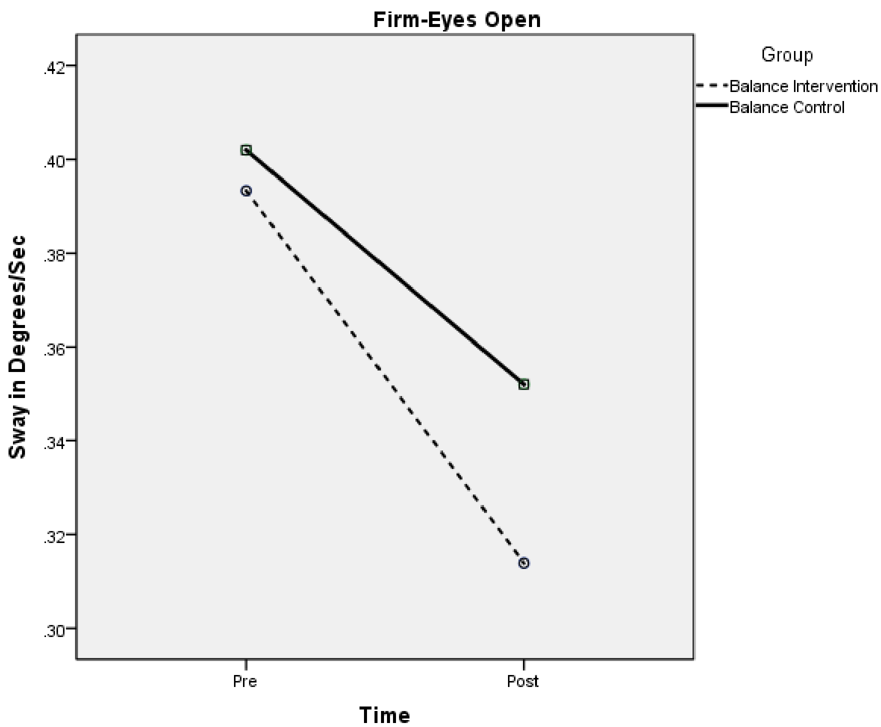


Figure 2. Overall Time Effect of Firm Eyes Closed (FIEC) by Group.

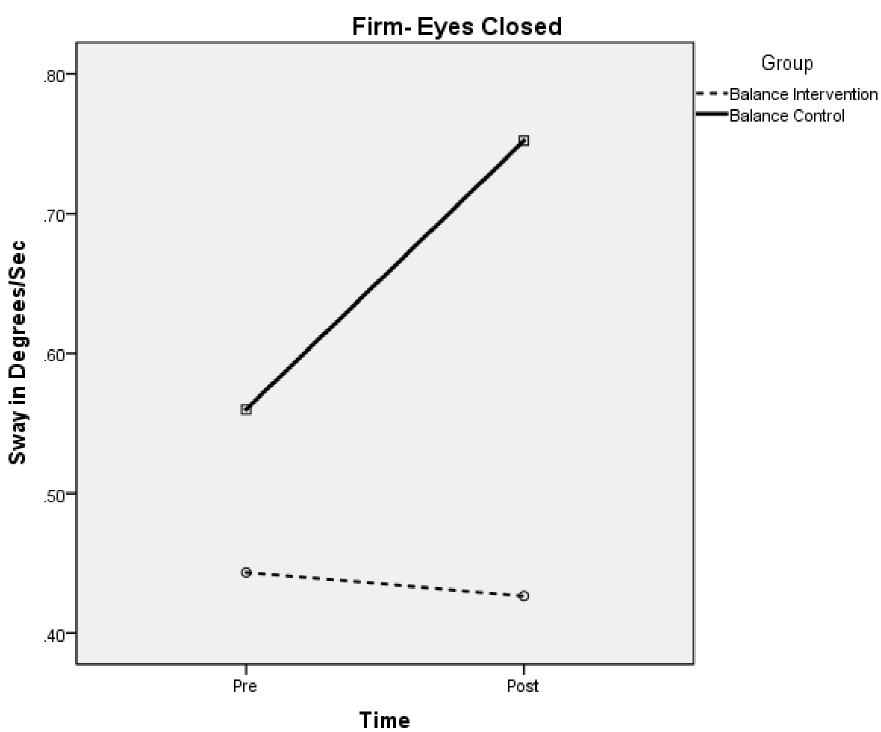


Figure 3. Overall Time Effect for Foam Eyes Open (FOEO) by Group.

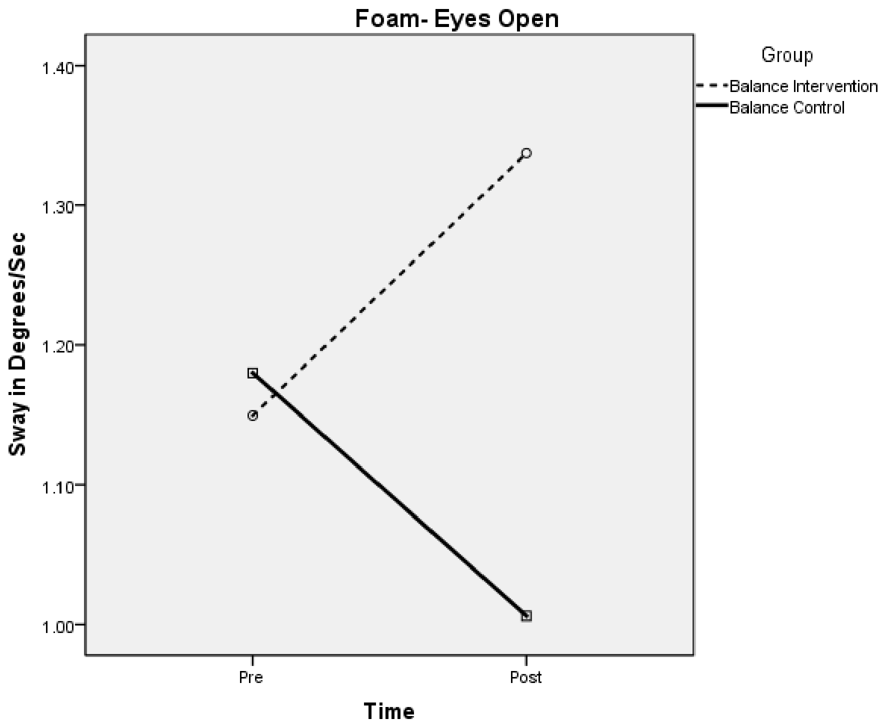
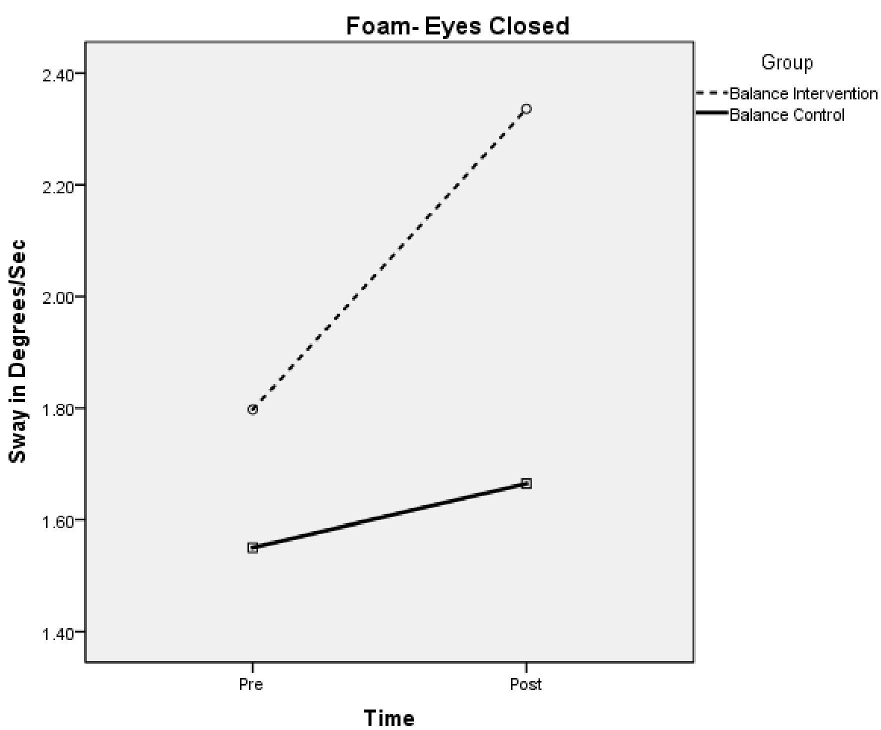


Figure 4. Overall Time Effect of Foam Eyes Closed (FOEC) by Group.



There was no significant time effect (p = 0.958), time by group interaction (p = 0.174), or group effect (p = 0.393) for the balance measure of standing on a foam surface with the eyes open. There was no significant time effect (p = 0.064), time by group interaction (p = 0.218), or group effect (p = 0.157) for the balance measure of standing on a foam surface with the eyes closed. The time*group interaction results indicate that sway measures for mCTSIB did not significantly decrease after participation in a 6-week balance training intervention when compared to the control group results, indicating no improvement in static balance from pre- to post-balance intervention in older adults.

A summary of the two-way ANOVA for dynamic balance measures by group (intervention vs. control) and time (pre- and post-intervention) is provided in Table 11 and descriptive statistics are provided in Table 10.

Table 10. Descriptive Statistics for the NeuroCom Dynamic Balance Variables by Total Sample and by Groups.

Variables	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
STS*	BAL INT	18	5.74±1.84	4.97±1.60	5.38±1.34
	BAL CON	5	5.19±0.53	6.27±0.77	-
TaW*	BAL INT	18	6.61±2.48	6.32±2.56	6.61±1.69
	BAL CON	5	8.95±1.63	6.79±2.50	-
SUO1**	BAL INT	18	33.85±11.49	33.97±8.77	33.98±9.48
	BAL CON	5	30.71±12.17	36.13±20.82	-
SUO2**	BAL INT	18	51.36±10.99	51.60±10.01	53.70±10.86
	BAL CON	5	49.01±17.93	61.53±23.98	-
SQT***	BAL INT	18	29.43±13.09	30.98±9.07	41.22±17.62
	BAL CON	5	50.47±14.42	48.67±17.02	-
SQTTT****	BAL INT	18	1.88±1.16	1.80±0.94	2.76±1.39
	BAL CON	5	3.33±1.79	3.11±1.82	-

*measured in degrees/sec sway
**measured in % of body weight
***measured in degrees/sec turn sway
****measured in turn time

Table 11. Two Way ANOVA for the NeuroCom Dynamic Balance Variables by Group (intervention vs. control) and Time (pre and post).

Variables	Source	df	SS	MS	F	p-value	Power	Effect Size
STS	Between Subjects							
	Group	1	1.102	1.102	0.352	0.559	0.088	0.017
	Error	21	65.685	3.128	-	-	-	-
	Within Subjects							
	Time	1	0.208	0.208	0.112	0.741	0.062	0.005
	Time*BalGroup	1	6.694	6.694	3.600	0.072	0.441	0.146
	Error	21	39.049	1.859	-	-	-	-
TaW	Between Subjects							
	Group	1	13.885	13.885	6.664	0.018*	0.690	0.250
	Error	21	41.672	2.084	-	-	-	-
	Within Subjects							
	Time	1	23.340	23.340	11.682	0.003*	0.901	0.369
	Time*BalGroup	1	13.885	13.885	6.664	0.018*	0.690	0.250
	Error	20	41.672	2.084	-	-	-	-
SUO1	Between Subjects							
	Group	1	1.858	1.858	0.007	0.933	0.051	0.000
	Error	21	5432.790	258.704	-	-	-	-
	Within Subjects							
	Time	1	60.136	60.136	2.809	0.109	0.359	0.118
	Time*BalGroup	1	55.042	55.042	2.571	0.124	0.334	0.109
	Time	21	449.507	21.405	-	-	-	-
SUO2	Between Subjects							
	Group	1	112.326	112.326	0.358	0.556	0.088	0.017
	Error	21	6583.896	313.519	-	-	-	-
	Within Subjects							
	Time	1	318.773	318.773	8.775	0.007*	0.806	0.295
	Time*BalGroup	1	295.409	295.409	8.132	0.010*	0.776	0.279
	Error	21	762.893	36.328	-	-	-	-
SQT	Between Subjects							
	Group	1	2932.838	2932.838	15.363	0.001*	0.962	0.422
	Error	21	4008.921	190.901	-	-	-	-
	Within Subjects							
	Time	1	0.124	0.124	0.001	0.973	0.050	0.000
	Time*BalGroup	1	21.935	21.935	0.200	0.659	0.071	0.009
	Error	21	2298.512	109.453	-	-	-	-
SQTTT	Between Subjects							
	Group	1	14.140	14.140	7.455	0.013*	0.740	0.262
	Error	21	39.829	1.897	-	-	-	-
	Within Subjects							
	Time	1	0.428	0.428	0.750	0.396	0.131	0.034
	Time*BalGroup	1	0.158	0.158	0.277	0.604	0.079	0.013
	Error	21	11.982	0.571	-	-	-	-

To evaluate dynamic balance, four NeuroCom measures were used: sit-to-stand (STS), tandem walk (TaW), step up and over (SUO), and the step/quick turn (SQT). The TaW analysis was run with the TaW pre scores as a covariate because groups were different at pre-test.

There were no significant time effects (*p* = 0.74), time by group interaction effects (*p* = 0.072), or group effects (*p* = 0.559) for STS. See Figure 7 for the plot of pre- to post-intervention STS values by group. Likewise, there were no significant time effects (*p* = 0.109), time by group interaction effects (*p* = 0.124), or group effects (*p* = 0.933) SUO1 lift up weight index. See Figure 9 for the plot of pre- to post-intervention SUO1 values by group.

There was a significant time effect (*p* = 0.003), group effect (*p* = 0.018), and time*group interaction (*p* = 0.018) for TaW. There was a significant group difference at pre for the intervention group (6.61) and the control group (8.95). The means at post-test were 6.32 for the intervention group and 6.79 for the control group. See Figure 8 for the plot of pre- to post-intervention TaW values by group. Both groups lowered their sway on the tandem walk from pre- to post-test, which shows the time*group interaction for the TaW. There could have been a practice effect because they did do this exercise during training. The participants were allowed to hold onto their chair during training; however, most of the participants did the tandem walk without holding on to the chair during training. The control group could have improved their tandem walk sway due to practice effect during testing. During testing, the participants were not allowed to hold onto anything, so they could have been comfortable doing it from practicing it during training.

There was a significant increase in SUO impact index (SUO2), which suggestss that the participants were not able to lift their foot up and over a box easily and they had to step down hard, from pre-test to post-test (*p* = 0.007) with mean scores of 50.85 at pre-test and 53.76 at post-test, indicating an increase in weight in their foot that stepped over the box. There also was a significant time by group interaction effect for SUO impact index ($p = 0.010$). The mean for the intervention group at pre-test was 51.36 and 51.60 at post-test, whereas the mean for the control group at pre-test was 49.01 and 61.53 at post-test. See Figure 10 for the plot of pre- to post-intervention SUO2 values by group.This indicates that the groups were similar at pre-test, but the control group performed significantly poorer at post-test. The differences from pre- to post-intervention for the SUO impact index produced a small effect size ($d = 0.29$).

There was a significant group effect for SQT turn sway ($p = 0.001$). The mean for the intervention group at pre-test was 29.43 and 30.98 at post-test, whereas the mean for the control group at pre-test was 50.47 and 48.67 at post-test. See Figure 11 for the plot of pre- to post-intervention SQT values by group. This shows a very large difference between groups at both pre- and post-intervention. The intervention group increased sway slightly over time, whereas the control group decreased sway over time, but the function of the control group continued to be much poorer than the intervention group. The differences from pre- to post-intervention for the SQT turn sway produced a small effect size ($d = 0.42$).

There was a significant group effect for SQT turn time ($p = 0.013$). The mean for the intervention group at pre-test was 1.93 and 1.84 at post-test, whereas the mean for the control group at pre-test was 3.42 and 3.04 at post-test, which indicates a decrease in turn time for both groups. See Figure 12 for the plot of pre- to post-intervention SQTT values by group. This shows a large difference between groups at baseline with both groups decreasing turn time at post-intervention when turning to the right side over time. However, there was a non-significant time*group interaction. The differences from pre- to post-intervention for the SQT turn time produced a medium effect size (d = 0.740). This could be due to the fact that the intervention group had completed the training and were more confident in their walking and balance. Whereas the control group might not have participated in any activity during the 6-weeks, causing them to not be as confident and moving slower when they turned. Overall, the results from the pre- to post-test indicate that participation in a 6-week balance training intervention resulted in a significant decrease in sway for the step/quick turn when turning to the left, an increase in sway for step/quick turn when turning to the right, and an increase in step up weight index for step up and over in older adults. This could be because the participants were more confident in walking and turning after the intervention which caused them to turn faster, but increase their sway. The participants lost all of their normal compensations during testing which also could have been a factor for why the participants had more sway. While the 6-week balance training intervention did not significantly improve all sway measures in balance, there were still functional improvements because they were able to move better and faster.

Figure 5. Overall Time Effect for Sit-to-Stand (STS) by Group.

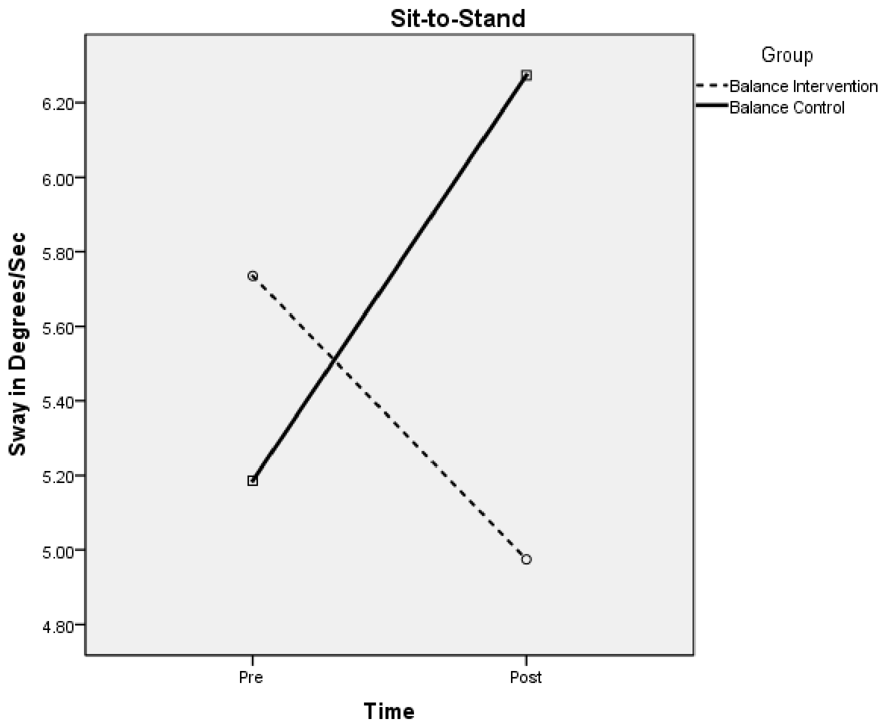


Figure 6. Overall Time Effect for Tandem Walk (TaW) by Group with TaWpre as the Covariate.

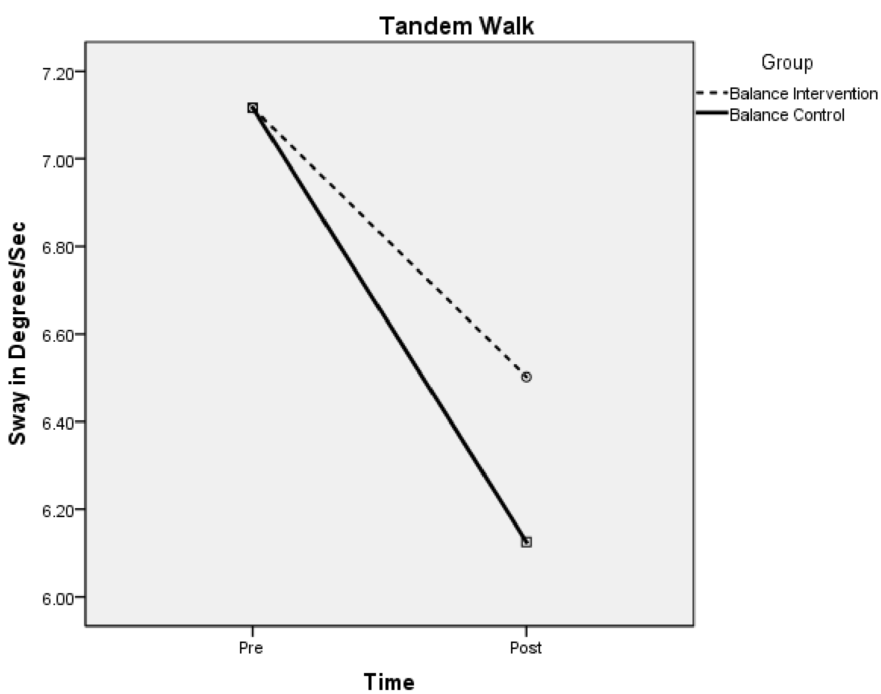


Figure 7. Overall Time Effect for Step Up and Over - Lift Up Index (SUO1) by Group.

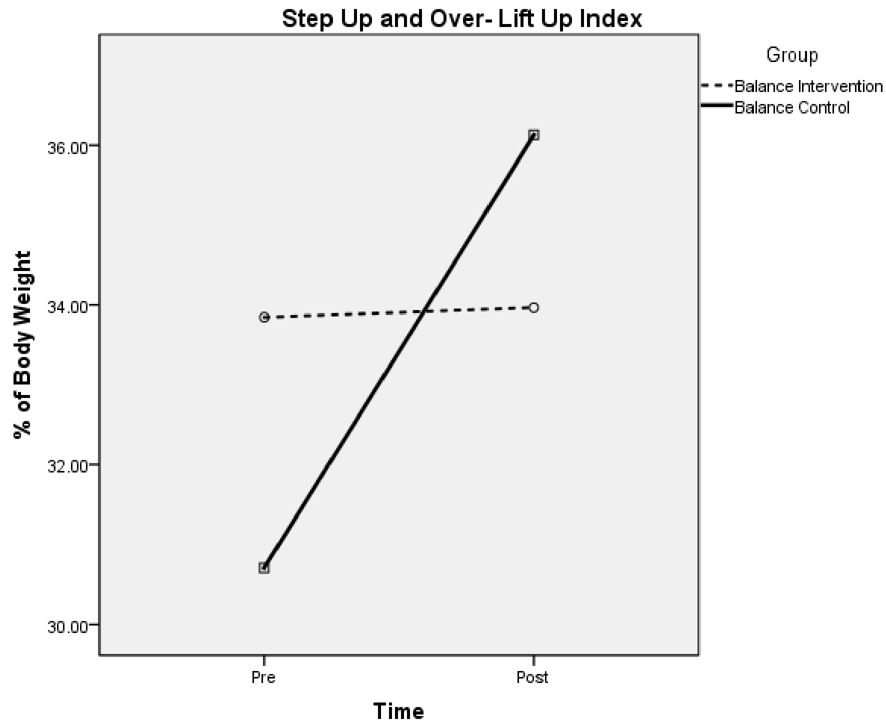


Figure 8. Overall Time Effect for Step Up and Over- Impact Index (SUO2) by Group.

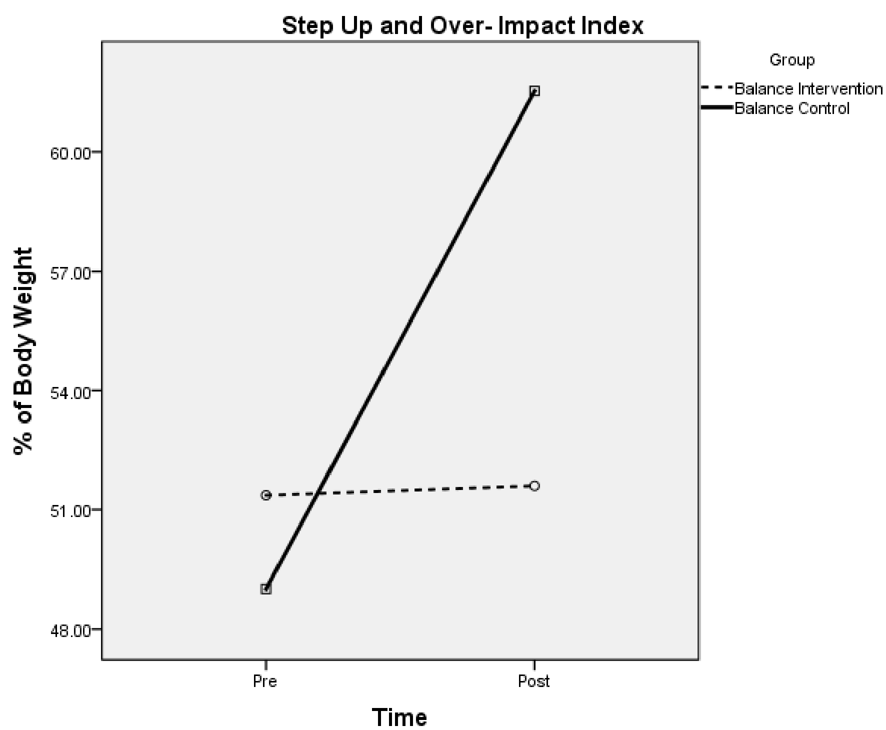


Figure 9. Overall Time Effect for Step Quick Turn (SQT) by Group.

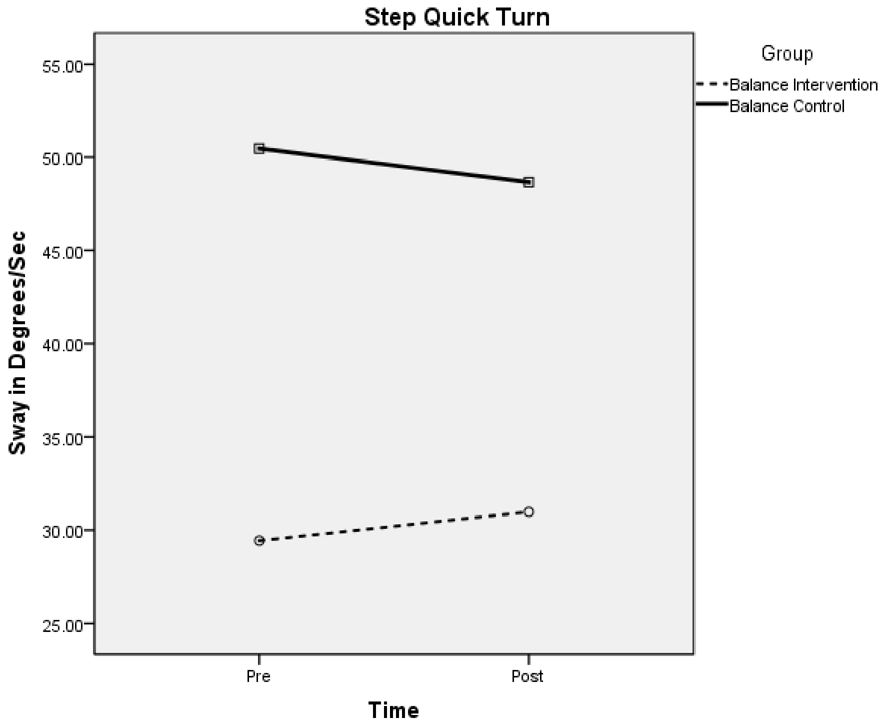
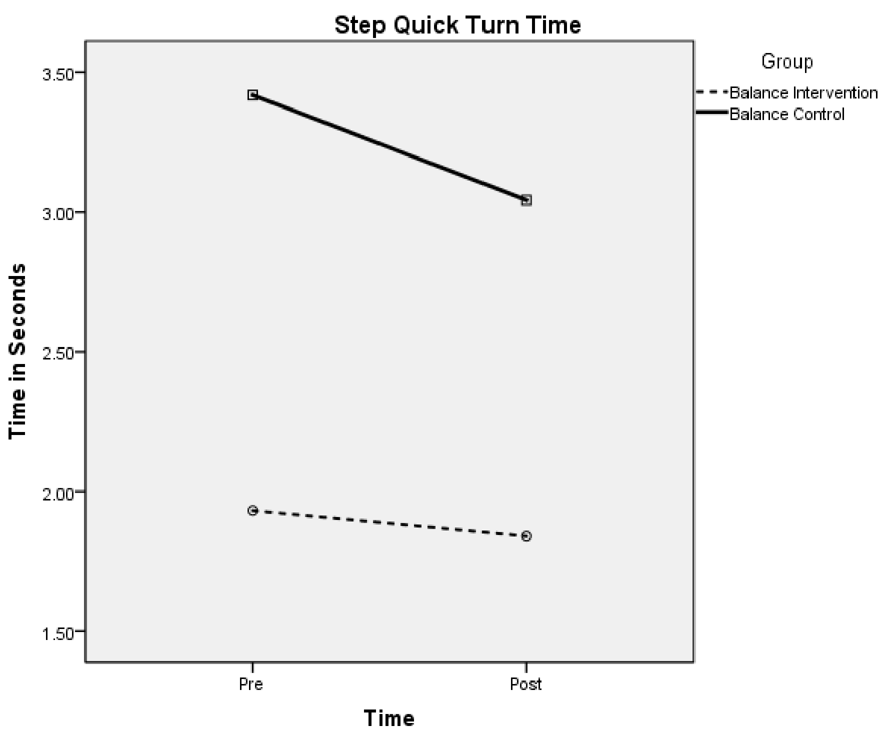


Figure 10. Overall Time Effect for Step Quick Turn Time (SQTTT) by Group.



A summary of the two-way ANOVA for functional balance measures by group (intervention vs. control) and time (pre- and post-intervention) is provided in Table 13 and descriptive statistics are provided in Table 12.

Table 12. Descriptive Statistics for Functional Balance Variables by Groups.

Variables	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
TUG******	BAL INT	18	9.4±2.3	8.4±1.7	8.1±1.9
	BAL CON	5	11.3±4.3	11.3±4.2	
TiW******	BAL INT	18	12.4±3.9	10.5±2.5	9.8±1.9
	BAL CON	5	11.9±2.2	12.9±3.5	

****** time measured in seconds

To evaluate functional balance, two measures were used: timed up & go (TUG) and timed walk (TiW). There was no significant group (p = 0.068), time (p = 0.240), or time by group (p = 0.202) effects for TUG with mean scores of 11.34 at pre- test and 11.3 at post-test for the control group, indicating no change in time required to performan the task. The mean for the intervention group was 9.4 at pre-test and 8.4 at post-test, which indicates improvement in perfprmance after completing the intervention. However, the mean time required to perform the TUG was fairly similar for the two groups, resulting in no significant between group effects. See Figure 15 for the plot of pre- to post-intervention TUG values by group.

There was no significant group effect (p = 0.518) or time effect (p = 0.548) for TiW. However, there was a significant time by group effect for TiW (p = 0.041) with mean scores of 11.9 at pre- test and 12.9 at post-test for the control group, indicating a increase in time and a decrease in performance. The mean for the intervention group was 12.4 at pre-test and 10.5 at post-test. See Figure 16 for the plot of pre- to post-intervention TiW values by group. This shows that the intervention group had a significant decrease in walk time, whereas the control group had an increase in walk time from pre- to post-test. The differences from pre- to post- intervention for the TiW produced a small effect size (*d* = 0.18).

Table 13. Two Way ANOVA for Functional Balance Measures by group (intervention vs. control) and Time (pre- and post-intervention).

Variables	Source	df	SS	MS	F	p-value	Power	Effect Size
TUG	Between Subjects							
	Group	1	45.082	45.082	3.694	0.068	0.450	0.150
	Error	21	256.289	12.204	-	-	-	-
	Within Subjects							
	Time	1	2.043	2.043	1.461	0.240	0.211	0.065
	Time*BalGroup	1	2.427	2.427	1.736	0.202	0.242	0.076
	Error	21	29.364	1.398	-	-	-	-
TiW	Between Subjects							
	Group	1	7.351	7.351	0.433	0.518	0.096	0.20
	Error	21	356.473	16.975	-	-	-	-
	Within Subjects							
	Time	1	1.300	1.300	0.373	0.548	0.090	0.17
	Time*BalGroup	1	16.446	16.446	4.722	0.041*	0.545	0.184
	Error	21	73.138	3.483	-	-	-	-

Overall, the results from pre- to post- test indicate participation in a 6-week balance training intervention resulted in no significant improvements in timed up & go, but they indicate that participation in the balance training intervention resulted in a decrease in time for the timed walk. Both groups improved on the walk time from pre- to post- intervention, with the intervention group having a slightly faster time. This could be due to the fact that the participants felt more confident in their ability to walk. Another reason could be because they understood the instructions differently from pre- to post- intervention so that caused them to walk faster.

Figure 11. Overall Time Effect for Timed Up & Go (TUG) by Group.

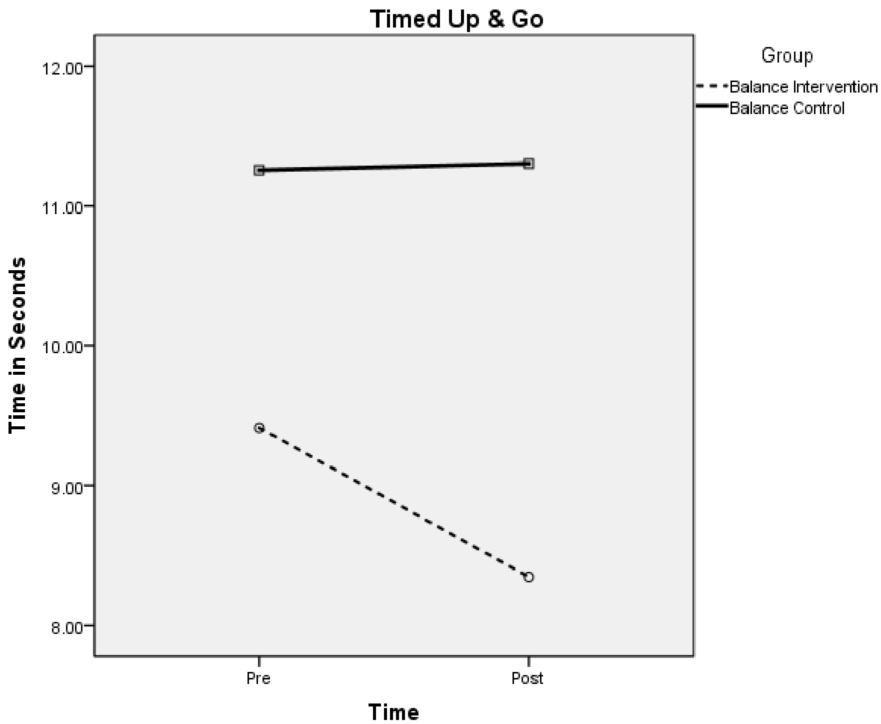
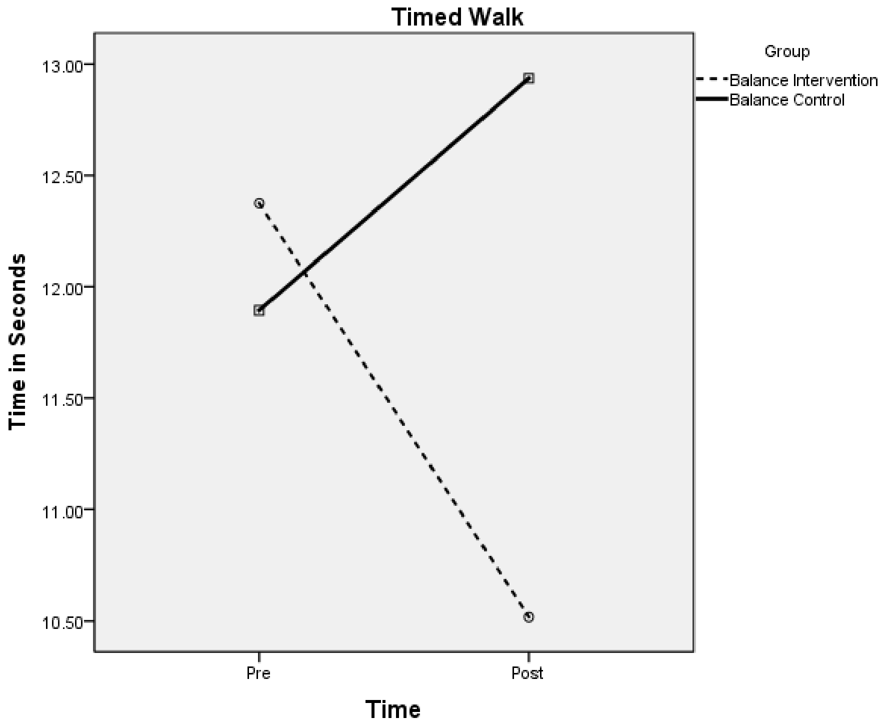


Figure 12. Overall Time Effect for Timed Walk (TiW) by Group.



Fear of Falling:

RQ2: Will fear of falling decrease after participation in a 6-week balance training intervention?

A summary of the two-way ANOVA for fear of falling by group (intervention vs. control) and time (pre- and post-intervention) is provided in Table 15. There was a significant decrease in FES score from pre-test to post-test ($p = 0.038$) with mean scores of 17.57 at pre-test and 12.96 at post-test for the total sample. The results indicated no significant group ($p = 0.156$) or time by group interaction effect ($p = 0.180$) for FES scores. The means for the intervention group was 15.22 at pre-test and 12.56 at post-test, whereas for the control group it was 26.00 at pre-test and 14.40 at post-test. While both groups had a decrease in FES scores which indicates a decrease in fear of falling, the control group had a significantly higher average at pre-test. The differences from pre- to post-intervention for the FES produced a small effect size (*d* = 0.19). Overall, the results from the pre- to post-test indicate that over time from pre- to post-intervention both groups FES scores decreased, but it is hard to say if it is because of the balance training intervention.

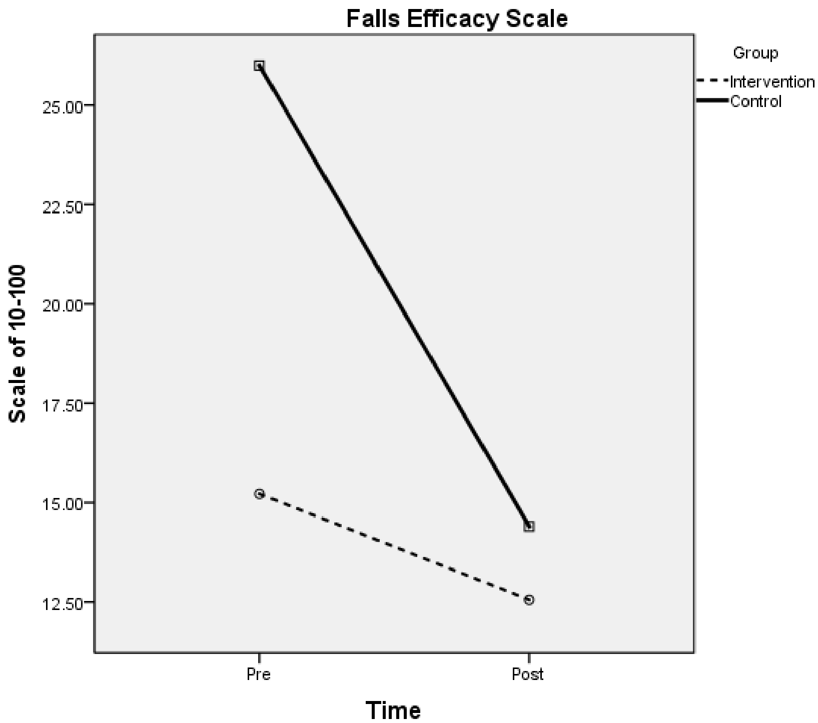
Table 14. Descriptive Statistics for Fear of Falling Variable by Total Sample and by Groups.

Variable	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
FES	BAL INT	18	15.2±9.3	12.6±4.3	13.1±5.3
	BAL CON	5	26.0±26.6	14.4±5.6	

Table 15. Two Way ANOVA for Falls Efficacy Scale by group (intervention vs. control) and Time (pre- and post-intervention).

Variable	Source	df	SS	MS	F	p-value	Power	Effect Size
FES	Between Subjects							
	Group	1	311.714	311.714	2.165	0.156	0.290	0.093
	Error	21	3023.156	143.960	-	-	-	-
	Within Subjects							
	Time	1	398.226	398.226	4.897	0.038*	0.560	0.189
	Time*BalGroup	1	156.139	156.139	1.920	0.180	0.263	0.084
	Error	21	1707.600	81.314	-	-	-	-

Figure 13. Overall Time Effect for Falls Efficacy Scale (FES) by Group.



Exercise Adherence:

RQ3: Will participants in a 6-week behavioral intervention have higher rates of adherence to maintenance of recommended balance exercises than those who do not receive the intervention?

A summary of the Independent T-Test for exercise adherence by group (intervention vs. control) is provided in Table 16. The participants that were in the balance intervention group were randomized into the behavioral intervention group and the behavioral control group. The balance exercise recommendation provided to the participants was to practice 120 minutes/week for the 6-week behavioral intervention. To evaluate exercise adherence, the total time (minutes) per week spent doing balance exercises was recorded. The number of falls each week also was recorded. No participants reported a fall during the 6-week behavioral intervention.

Table 16. Between Group Differences for Balance Exercise Total Minutes/Week and Number of Falls.

Variable	Group	n	Mean ± SD	t (df)	p-value
Total Minutes/Week	ADH INT	7	137.14±57.07	2.886 (10)	0.008*
	ADH CON	5	48.00±45.48		
Falls	ADH INT	7	0		
	ADH CON	5	0		

*Exercise Time = Total Time Per Week

There was a significant difference in the amount of time spent exercising between the behavioral intervention group and the control group (p = 0.008). The intervention group had a mean time of 137.14 minutes per week, whereas the control group had a mean time of 48 minutes per week. Five out of the seven participants from the intervention group achieved the recommended balance exercise goal of 120 minutes/week during every week of the behavioral intervention. None of the participants in the control group met the recommended balance exercise goal during the behavioral intervention. These findings suggest that the behavioral intervention was effective in increasing behavioral adherence during the follow-up period with the intervention group showing significantly higher adherence in comparison to the control group.

Balance Adherence:

RQ4: Does balance improve from post-test (the end of the balance training intervention) to follow-up assessment among balance training participants?

A summary of the two-way ANOVA for only the intervention group for functional mCTSIB measures by time (post and follow-up) is provided in Table 18.

Table 17. Descriptive Statistics for the NeuroCom Static Balance Variables for the Intervention Group.

Variables	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
FIEO*	BAL INT	18	0.39±0.16	0.31±0.13	0.38±0.18
FIEC*	BAL INT	18	0.44±0.26	0.43±0.32	0.38±0.23
FOEO*	BAL INT	18	1.15±0.31	1.34±0.54	1.19±0.36
FOEC*	BAL INT	18	1.79±0.57	2.34±0.76	1.75±0.74

*measured in degrees/sec sway

Table 18. Two Way ANOVA for the NeuroCom Static Balance Variables by Time (post and follow-up) and Group (Adherence Intervention and Adherence Control).

Variables	Source	df	SS	MS	F	p-value	Power
FIEO	Within Subjects						
	Time	1	0.062	0.062	8.305	0.016*	0.738
	Time*AdhGroup	1	0.030	0.030	4.000	0.073	0.440
	Error	10	0.074	0.007	-	-	-
FIEC	Within Subjects						
	Time	1	0.018	0.018	0.988	0.344	0.147
	Time*AdhGroup	1	0.029	0.029	1.631	0.230	0.212
	Error	10	0.180	0.018	-	-	-
FOEO	Within Subjects						
	Time	1	0.082	0.082	0.366	0.559	0.085
	Time*AdhGroup	1	0.112	0.112	0.500	0.496	0.098
	Error	10	2.241	0.224	-	-	-
FOEC	Within Subjects						
	Time	1	1.880	1.880	12.593	0.005*	0.891
	Time*AdhGroup	1	0.024	0.024	0.159	0.016*	0.065
	Error	10	1.493	0.149	-	-	-

There was a significant time effect (p = 0.016) for FIEO from post- to follow-up test with mean scores of 0.32 at post-test and 0.38 at follow-up test, indicating an increase in sway. There was no significant time*group interaction (p = 0.073) for

FIEO. There was no significant time effect (*p* = 0.344) or time*group interaction (*p* = 0.230) for FIEC from post- to follow-up test. There also was a significant time effect (*p* = 0.005) for FOEC from post- to follow-up test with mean scores of 2.34 at post-test and 1.75 at follow-up test, indicating a decrease in sway from post-intervention to follow-up. There was a significant time*group interaction (*p* = 0.016) for FOEC, with a decrease in sway over time. However, there was no significant time effect (*p* = 0.559) or time*group interaction (*p* = 0.496) for FOEO from post- to follow-up test.

The results indicate that participants' sway increased on the firm surface with the eyes open, but sway decreased on the foam surface with the eyes closed. Postural sway did not change for firm surface with eyes closed and foam surface with eyes open from post- to follow-up test following a 6-week behavioral intervention for older adults. This shows us that while the participants did not significantly improve their sway, they were able to maintain their sway from post- test to follow-up test. Older adults often lose their gains quickly, but the participants were able to maintain their sway after the 6-week behavioral intervention.

Table 19. Descriptive Statistics for the NeuroCom Dynamic Balance Variables for the Intervention Group.

Variables	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
STS*	BAL INT	18	5.74±1.84	4.97±1.60	5.38±1.34
TW*	BAL INT	18	6.61±2.48	6.32±2.56	6.61±1.69
SQT***	BAL INT	18	29.43±13.09	32.48±10.45	39.52±14.51
SQTTT****	BAL INT	18	1.93±1.20	1.84±0.88	2.56±1.28
SUO1**	BAL INT	18	33.85±11.49	33.97±8.77	33.98±9.48
SUO1**	BAL INT	18	51.36±10.99	51.60±10.01	53.70±10.86

*measured in degrees/sec sway
**measured in % of body weight
***measured in degrees/sec turn sway
****measured in turn time

A summary of descriptive data and the two-way ANOVA results for only the intervention group for dynamic balance measures by time (post-intervention to 6-weeks post-intervention follow-up) are provided in Table 19 and Table 20.

Table 20. Two Way ANOVA for the NeuroCom Dynamic Balance Variables by Time (post-intervention and follow-up) and Group (Adherence Intervention and Adherence Control).

Variables	Source	df	SS	MS	F	p-value	Power
STS	Within Subjects						
	Time	1	2.423	2.423	5.243	0.045*	0.543
	Time*AdhGroup	1	0.172	0.172	0.372	0.556	0.086
	Error	10	4.621	0.462	-	-	-
TaW	Within Subjects						
	Time	1	0.385	0.385	0.123	0.733	0.062
	Time*AdhGroup	1	0.109	0.109	0.035	0.855	0.053
	Error	10	31.242	3.124	-	-	-
SQT	Within Subjects						
	Time	1	288.769	288.769	3.179	0.105	0.364
	Time*AdhGroup	1	0.002	0.002	0.000	0.996	0.050
	Error	10	908.427	90.843	-	-	-
SQTTT	Within Subjects						
	Time	1	2.419	2.419	4.506	0.060	0.483
	Time*AdhGroup	1	0.124	0.124	0.232	0.641	0.072
	Error	10	5.370	0.537	-	-	-
SUO1	Within Subjects						
	Time	1	12.005	12.005	1.547	0.242	0.203
	Time*AdhGroup	1	0.810	0.810	0.104	0.753	0.060
	Time	10	77.592	7.759	-	-	-
SUO2	Within Subjects						
	Time	1	49.737	49.737	1.125	0.314	0.161
	Time*AdhGroup	1	1.344	1.344	0.030	0.865	0.053
	Error	10	442.204	44.220	-	-	-

There was a significant time effect (p = 0.045) for STS from post- to follow-up test with mean scores of 5.26 at post-test and 5.38 at follow-up test, indicating an increase in sway. There were no significant time effects for TaW (p = 0.733), SQT turn sway (p = 0.084), SQT turn time (p = 0.60), SUO lift up weight index (p = 0.242), or SUO impact index (p = 0.314) from post- to follow-up test. There also were no significant time*group interactions for STS (*p* = 0.556), TaW (*p* = 0.855), SQT (*p* = 0.996), SQT turn time (*p* = 0.641), SUO lift up weight index (*p* = 0.753), or SUO impact index (*p* = 0.865) from post- to follow-up test. The results indicate that participants sway increased on the sit-to-stand, but there were no significant changes in tandem walk, step/quick turn sway, step/quick turn time, and step up and over weight index from post- to follow-up test following a 6-week behavioral intervention for older adults. The participants were used to doing multiple sit-to-stand maneuvers during the intervention and did not practice just doing one sit-to-stand, so this could may caused them to have more sway when they stood up because we took away any normal compensatory mechanisms that they might typically use.

A summary of descriptive data and the two-way ANOVA for only the intervention group for functional balance measures by time (post-intervention to follow-up) are provided in Table 21 and Table 22.

Table 21. Descriptive Statistics for Functional Balance Variables for the Intervention Group

Variables	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
TUG*****	BAL INT	18	9.4±2.3	8.4±1.7	8.1±1.9
TiW*****	BAL INT	18	12.37±3.86	10.51±2.52	9.81±1.98

*****measured in time in seconds

Table 22. Two Way ANOVA for Functional Balance Measures by Time (post and follow-up) and Group (Adherence Intervention and Adherence Control).

Variables	Source	df	SS	MS	F	p-value	Power
TUG	Within Subjects						
	Time	1	0.195	0.195	0.407	0.538	0.089
	Time*AdhGroup	1	0.112	0.112	0.235	0.638	0.072
	Error	10	4.781	0.478	-	-	-
TiW	Within Subjects						
	Time	1	0.097	0.097	0.186	0.675	0.0.068
	Time*AdhGroup	1	4.266	4.266	8.165	0.017*	0.731
	Error	10	5.225	0.522	-	-	-

There was no significant time effect ($p = 0.538$) or time*group interaction ($p = 0.638$) for TUG from post-intervention to follow-up test. Likewise, there was no significant time effect ($p = 0.675$) for TiW from post-intervention to follow-up. There was a significant time*group interaction ($p = 0.017$) for TiW from post-intervention to follow-up test with mean scores of at 11.04 post-test and 9.81 at follow-up test, indicating a decrease in time required to complete the timed walk.

The results indicate that participants time improved on the timed walk, but performance on the timed up & go did not change from post- to follow-up test following a 6-week behavioral intervention for older adults. The timed up and go may not have had significant changes because the participants were not trained during the intervention the same way the assessment is conducted. Also, any compensation that the participants normally used to maintain balance were restricted. For instance, they were not allowed to use their hands for standing up or sitting down, which may have impacted their performance. The timed walk could have improved because the participants became more active and more confident in their ability to walk after the intervention.

It should be noted that although performance on many of balance outcome measures did not improve during the 6 weeks between post-intervention to follow-up, performance on these balance parameters did not significantly decline, which for this age group may be an indication of the efficacy of the balance exercises on at least maintaining function.

Fear of Falling Adherence:

RQ5: Does fear of falling decrease from post-test to follow-up assessment?

A summary of the two-way ANOVA for only the intervention group for Falls Efficacy Scale by time (post and follow-up) is provided in Table 24. There was no significant time effect (p = 0.803) or time*group interaction (p = 0.330) for FES from post- to follow-up test. The results indicate that fear of falling did not change from post- to follow-up test following a 6-week behavioral intervention for older adults.

Table 23. Descriptive Statistics for Falls Efficacy Scale for the Intervention Group

Variables	Group	n	Pre-Test Mean ± SD	Post-Test Mean ± SD	Follow-Up Mean ± SD
FES	BAL INT	18	12.37±3.86	10.51±2.52	9.81±1.98

Table 24. Two Way ANOVA for Falls Efficacy Scale by time (post to follow-up) and Group (Adherence Intervention and Adherence Control).

Variable	Source	df	SS	MS	F	p-value	Power
FES	Within Subjects						
	Time	1	0.233	0.233	0.066	0.803	0.056
	Time*AdhGroup	1	3.733	3.733	1.049	0.330	0.153
	Error	10	35.60	3.560	-	-	-

Process Evaluation

Detailed records were kept through the duration of the study to evaluate the effectiveness of the intervention. Distribution of activity and fall logs were given to each participant at the post-test meeting. Emails were sent weekly to those in the intervention group with motivation and reminders to fill out the logs. There were only one or two participants that actually responded to the emails saying thank you for the reminders.

A couple of the participants did not have the logs to turn into me at the follow-up testing. The participants were not asked to turn them in each week, as most of them did not have access to a computer, which made it difficult for them to get the logs to me. They were just asked to keep track of the logs over the six weeks and to bring them back at follow-up testing. Several participants noted that it got difficult over time to keep track and some of them had so much going on that they did not have time to complete the exercises. A more efficient tracking system for the balance exercises might help address this issue in future studies.

Phone calls were made every other week during the intervention and exit surveys were filled out at the end of the study. Two participants received phone calls each week because they did not have email addresses. Of the 12 participants that completed follow-up testing, 11 of them completed the exit survey, but answers were very brief. Several participants noted that the use of emails was not effective, but rather in-person would have been better for reminders. While this would take extra time, it would be more likely that participants completed the balance exercises during the 6-week behavioral intervention.

Participants were generally satisfied with the intervention, but stated it was hard to do the balance exercises when they were asked to do them on their own. Twenty-eight participants volunteered for the study, but five of them had to drop out due to ongoing injuries and because they said it was harder than they expected it to be. Another six dropped from post-test to follow-up testing because they were injured after the completion of the balance training intervention. They all mentioned that the injuries were not because of the balance exercises or a fall, but rather something else they did. Weather did not seem to affect the participants in going to classes or testing.

The participants generally had a good time in the class each day. They seemed to keep coming because they were able to socialize with others just like them. They also mentioned that they felt like their balance was improving and they could do daily activities more easily because of the balance exercises. While there were not any significant improvements in balance, there were still participants that felt like they had improved. This could be due to the fact that with aging adults start to develop compensations in order to stabilize themselves. These compensations were taken away during testing, which could be a reason for why there were not any significant changes in the NeuroCom Balance Master® measures. The perceived improvements in balance were promising, and is important for future research.

Discussion of Results

The results obtained from this study revealed that participation in a 6-week balance training intervention was associated with improvement in timed walk time and turn sway to the left and a decrease in fear of falling. There have been other studies that have showed a decrease in fear of falling after an intervention (Tennstedt et al., 1998) and an improvement in balance after a tai-chi intervention (Li et al., 2005) for older adults.

In this study, most of the postural sway outcome measures on the NeuroCom Balance Master® did not indicate a significant improvement after participation in a balance training intervention. A possible explanation for the inconsistencies in balance measures with previous literature might be related to differences in measurement techniques to evaluate balance. There are several different ways to measure balance and there is not a standard measure for balance. The NeuroCom Balance Master® is a laboratory based balance measure that provides a direct measure of postural sway that yields a highly sensitive measure of sway around the center of gravity. Each of the measures has a different sensitivity to balance. Some of the participants noted that they had bad ankles and had problems with their knees. This could have resulted in poor ankle control during testing, which is critical in performing the tasks on the NeuroCom Balance Master®. During the testing, the participants were not allowed to use their normal compensations they use in every day life. This could have been a reason for why there were no significant improvements in balance. The participants were allowed to use their normal compensations during training, so they were used to that and it did not translate when they did the tests. The data obtained from the NeuroCom Balance Master is quite sensitive test in that it measures postural sway, a key component of functional balance. However, these measures may be less specific tests for measuring performance on the functional tasks that were practiced during the balance training intervention. Other studies have used functional measures like single or double leg stand, ability to perform activities of daily living (ADLs), or the Berg Balance Scale. Studies that use functional measures have showed an improvement in balance (Seidler, 1997). Many studies with older adults using the NeuroCom Balance Master® do not use it to assess balance after an intervention, it is used to assess gait problems and balance for those after a stroke or head injury (Liston, 1996; Riemann, 2000). Thus, studies using different balance measures following a balance intervention may yield different results.

Timed walk, which was a functional measure of balance, significantly decreased over time. The intervention group decreased time from pre- to post-test and also from post-test to follow-up test. This could be due to the fact that they were more active because they were participating in the balance intervention, which made them more confident in their walking. The Timed Up and Go (TUG) is another functional measure of balance, which involves turning, sit-to-stand skills, and normal walking straight gait (Jehu, 2016). Previous studies have found that balance training can improve TUG in the intervention group compared to the control group (Jehu, 2016). This finding is was not supported in this study, and it could be due to the lack of turning training in the balance training intervention.

One reason why there was an increase in turn sway to the right, but a decrease in sway to the left side is because the participants might have become more confident in turning to the right so they actually turned faster, which increased their sway. The turn time decreased over time for both groups, so they turned faster in both directions. There were no exercises in the intervention that specifically trained them in turn mechanics, so that could be why there were differences in the right and left turn sway. There is no previous literature on turn sway differences following a balance training intervention with the older adult population.

There was a decrease in fear of falling after the 6-week balance training intervention. This study used the Falls Efficacy Scale, which actually measures the participants' confidence level in performing certain daily activities without falling.

Thus, it is based on the definition that those that have a fear have a low perceived self-efficacy at avoiding falls during daily activities (Tinetti, Richman, & Powell, 1990). This might not be the best measure for fear of falling with older adults, but has been used in several previous studies with this population. However, another study has used the FES to measure falls efficacy following an intervention that included strength exercises, walking, and balance exercises and found a significant improvement in the participants falls efficacy ($p = 0.028$) (Bishop, 2010). This was following a 12-week intervention, so it was longer in duration compared to the current study and could be a reason why they saw significant changes (Bishop, 2010). The reason for the decrease in fear of falling could be because several of the participants said they felt like they were able to get around more easily to do daily activities without feeling like they were going to fall over.

The participants in the intervention group during the behavioral intervention had a higher mean time of participating in the balance exercises compared to the control group. This suggests that having a behavioral intervention encourages participants to continue doing the exercises on their own. The group of participants also liked working together and exercising together, so another reason might be that they motivated each other to continue practicing the exercises. To date, there have been no other studies examining balance exercise adherence following a balance training intervention. There was one study that evaluated resistance training, balance exercises, and aerobic training following release from physical therapy (Forkan, 2006). The authors found no significance difference when looking at adherence rates, and barriers were the greatest impact on post discharge exercise participation (Forkan, 2006). It is hard to compare exercise adherence rates from this study with previous literature because there are no other studies.

Overall, the results of this study showed that laboratory measures of balance showed no significant improvements, but a performance-based measure of balance (timed walk) improved significantly after a 6-week balance training intervention. There was also a significant decrease in fear of falling after a 6-week balance training intervention. The benefits achieved after participating in a 6-week balance training intervention in the area of performance based balance and fear of falling are consistent with previous studies. The benefits achieved in the area of laboratory based balance measures were inconsistent and inconclusive.

Chapter V: Conclusions and Recommendations

Conclusions

The purposes of this study were twofold. The first objective was to determine the effect of participation in a 6-week balance training intervention on balance and fear of falling in older adults between 70-90 years old. The second objective was to assess the impact of participation in a behavioral intervention on balance exercise adherence rate, rate of falls, balance and fear of falling at 6-weeks follow-up in older adults. Several conclusions can be made from these results. Conclusions based on study results are organized by research questions.

RQ1: Will balance improve after participation in a 6-week balance training intervention?

H_R1: Balance will improve from pre-test to post-test after participation in a 6-week balance training intervention.

The null hypothesis was retained for research question number one in relation to some NeuroCom Balance Master® scores and one of the functional balance measures (Timed Up and Go). Comparison of scores for mCTSIB, Sit-to-Stand, Tandem Walk, Step Up and Over lift up index, and Timed Up and Go from pre- to post- test indicated no significant improvement in older adults after participating in a 6-week balance training intervention. One possible explanation for the lack of change in some of the laboratory balance measures is that the NeuroCom Balance Master® device has greater specificity and sensitivity than other balance measures. The NeuroCom Balance Master® measures the amount of sway around the participants' center of gravity and can do this to the hundredth of a degree of sway, whereas many other balance measures only assess the ability to carry out a task. If a participant is able to perform the task s/he is considered to have good balance, however these measures do not take into account the amount of sway that was involved in completing the task. The NeuroCom Balance Master® requires a participant to have good ankle control and some participants said that they had bad ankles, which could also be a reason for the lack of improvement with the balance training. A discussion of the findings for the balance tests follows:

- Another possible explanation for the non-significant changes in the measures of balance could be related to the balance exercises performed, the duration of the intervention and the dose of exercise (the amount of exercise time and level of intensity and frequency). Most of the exercises were static measures except for the walking exercises. Also, the participants had a chair next to them for all of the exercises in case they needed to hold on. This was an important safety precaution given the advanced age of participants. The participants could have relied too heavily on the chair to help hold them up during, which was not an option during testing. This may have contributed to nonsignificant changes on some of the NeuroCom Balance Master® measures. The participants did start doing the exercises on a foam pad, which helped to train them using a compressible surface, but again, they were able to hold on to the chair. The participants reported that several of the exercises were very challenging for them because closing their eyes and standing on the foam pad made them more unstable and increased their fear of falling. The 6-week time frame for the class could have been too short to produce significant changes, however, the total dose of exercise (number and duration of classes) was consistent with other longer duration training programs reported in the literature. With this age group, it may be important to have more total classes so that participants are exposed to the balance exercises over a longer period of time. Also, the small sample size, which reduced statistical power, could be a reason for the non-significant changes.

- Many of the exercises trained the participants on the mechanisms used during these tests. This should result in improvements in the balance tests following the intervention because they were practicing them at least three times a week. Comparison of total scores (intervention + control) from pre- to post-test for Step Quick Turn Sway when turning to the right, Step Quick Turn Sway when turning to the left, Step Quick Turn time when turning to the right, Step Quick Turn time when turning to the left, Step Up and Over Impact Index, and Timed Walk indicated a significant change after participating in a 6-week balance training intervention. The intervention group compared to the control group had a lower sway when turning to the right (pre-27.31, post-29.96; pre-46.40, post-47.22) and when turning to the left (pre-32.04, post-31.89; pre-54.52, post-50.11). The intervention group compared to the control group had a lower turn time when turning to the right (pre-1.88, post-1.80; pre-3.33, post-3.11) and when turning to the left (pre-1.89, post-1.88; pre-3.50, post-2.97). The control group had a much higher turn sway on both sides and turn time on both sides, this could be because they were not practicing walking turns, which can be difficult for older adults. The Step Up and Over Impact Index was slightly lower in the intervention group compared to the control group (pre-33.85, post-33.97; pre-30.71, post-36.13). The Timed Walk time decreased for both the intervention group and the control group (pre-12.4, post-10.5; pre-11.9, post-12.9). The control group seemed to impact the significant changes in these balance measures the most from pre-intervention to post-intervention.

- The Step Quick Turn sway to right increased and the Step Up and Over Impact Index weight increased, which indicate a decline in function. The Step quick turn sway to left decreased, the Step Quick Turn time to the right and left decreased, and the Timed Walk time decreased, which indicate an improvement in performance. The Step Quick Turn measures turn sway, which is different than the other measures on the NeuroCom Balance Master®. This type of maneuver may reflect stability during turning while walking, especially if the turn is made while walking fast. This test requires participants to take two steps forward, turn 180 and return to the starting point. Turn sway reflects the sway during execution of the turn. The turn time decreased when turning to the right and left side for both the intervention group and the control group; however, the intervention group had a greater reduction in turn time. The intervention group could have become more confident and were able to turn faster. The control group could have decreased their turn time because of practice effect. The participants were allowed to try it at least one time before actual testing. Because the participants in the control group only did the testing, they could have remembered the test, which may have made them feel confident enough to turn faster. Turning was not necessarily trained during each balance training class, but some of the exercises could have made them feel more comfortable with turning.

- The Step Up and Over Impact Index is the amount of impact weight of the foot that was lifted over the box put down while stepping down on to force plate. The goal of this test is for participants to be able to control the impact force of the leg that is swinging over the "curb". An increase in impact weight indicates a decline in function because it suggests that they were not able to control the leg that was swinging over the "curb" well. This could have negative implications for functional tasks such as stepping up or down from a street curb. Both groups showed an increase in impact weight from pre- to post-test. The groups were very similar at pre-intervention and the intervention group remained stable over the six weeks while the control group had a much higher impact weight at post-test. Also, some participants noted that the test hurt their knees and hips, so some of them were not actually able to do it properly because they needed assistance. Members of the control group held on to the testers at times to stabilize themselves so that they would not fall.
- The Timed Walk is a functional measure of balance, and the functional measures of balance typically improve after balance training interventions. The time it took for participants to walk a distance that was equal to a two-lane road cross walk decreased from pre- to post- test. There were a lot of walking exercises in the balance training, which could explain why they improved. Also, because they were taking the classes, the participants were likely to be more active, which could also improve their walk time.

RQ2: Will fear of falling decrease after participation in a 6-week balance training intervention?

H_R2: Fear of falling will decrease from pre-test to post-test after participation in a 6-week balance training intervention.

The hypothesis for research question number two was supported by the results. Comparison of scores on the Falls Efficacy Scale from pre- to post-test between the intervention and control groups indicated a significant decrease in fear of falling for the intervention group after participating in a 6-week balance training intervention. Fear of falling is a strong predictor of falls (Ersoy, 2009). Balance training should improve fear of falling because it works on getting older adults out of their comfort zone and doing exercises that work on strength and balance, which is associated with physical performance (Gusi, 2012). A decrease in fear of falling scores shows an improvement in performance, meaning they were more confident in their ability to carry out daily activities without falling. Other studies have shown a decrease in fear of falling after a balance training intervention (Gusi, 2012; Lin, 2006). One study found that the participants that started with poor scores on balance and fear of falling were more likely to see improvements after balance training (Gusi, 2012), which could be the case for this study as well. A possible reason for the positive impact of balance training on fear of falling may be the fact that intervention participants became more aware of their balance. Several participants commented that they were able to move around more easily after doing the exercises three times a week. The dynamic balance exercises like the tandem walk, walking backwards, and walking on toes, as well as the static exercises like the one leg stand, half tandem stand, and full tandem stand with the eyes closed seemed to have a positive impact on the participants' self-efficacy and ability to perform daily activities without falling. Participants indicated that they increased their levels of physical activity because they were training three days a week, which may have resulted in them becoming more confident in their ability to be more active. The class also might have helped participants build up more stamina to be able to perform more activities than previous to training. Some of the exercises were strength exercises for the lower body, which could help the participants walk more efficiently and do their activities more easily. All of these things combined could have improved the participants' confidence to be able to perform designated activities without falling.

RQ3: Will participants in a 6-week behavioral intervention have higher rates of adherence to maintenance of recommended balance exercises than those who do not receive the intervention?

H_R3: Adherence rates will be higher in participants of a 6-week behavioral intervention as compared to those who did not participate in the intervention.

The hypothesis for research question three was supported by the results. Comparison of scores on balance exercise adherence rates indicated a significant difference between the intervention group and the control group, with the total minutes of balance exercises practiced per week being significantly higher for the intervention group as compared to the control groups. The participants receiving the behavioral intervention should have had higher rates of adherence compared to the control group because they received additional motivation from emails and phone calls, which the control group did not receive. This indicates that the intervention group did adhere to the recommended balance exercises and had higher rates of exercise time compared to the control group. A possible reason for the significant difference could be the fact that the group of intervention participants were more motivated to continue exercising after the balance training intervention concluded. In general, participants commented that they wanted to continue the exercises because they felt like their balance improved and they did not want to go back to feeling as they did before. The participants that were in the behavioral intervention group received an email each week reminding them to do their exercises and fill out their logs. They also received a tip to help them continue exercising. These emails were designed to motivate the participants to keep up with the exercises. One suggestion to get everyone to continue doing the exercises on their own is to have a stronger stimulus control (such as reminders or incentives) for older adults. None of the participants reported a fall during the 6-week behavioral intervention, which shows that they had improved balance and some of them commented that they made some changes to their home (i.e. removed clutter from the floor and changed lighting in the bedroom) after receiving the education material.

RQ4: Does balance remain stable or improve from post-test (the end of the balance training intervention) to follow-up assessment?

H_R4: Balance measures of participants of a 6-week behavioral intervention will remain stable or be better at follow-up assessment than those who did not participate in the intervention.

The null hypothesis was retained for research question four in relation to some of the NeuroCom Balance Master measures and one of the functional balance measures (Timed Up and Go). Comparison of scores for mCTSIB (FIEC and FOEO), Tandem Walk, Step Quick Turn to the left, Step Up and Over lift up index, Step and Up Over impact index, and Timed Up and Go indicated no significant change from post-test to follow-up test after a 6-week behavioral intervention. This shows that there was no decline or improvement in their performance on the balance measures following the balance intervention, which means they were able to maintain over the 6-week follow-up period. A discussion of the balance findings follows:

- As noted previously, the majority of NeuroCom Balance Master tests did not change from post-balance intervention to follow-up. This is quite positive in this age group because of the maturational declines in function that occur naturally over time. Maintaining stable function/balance suggests that these maturational declines can be slowed by participation in balance training. The movements involved in some of the measures like the Step Up and Over and Step Quick Turn were not targeted in the training exercises provided to the participants so that could be a reason for the lack of change.
- Comparison of scores for mCTSIB (FIEO and FOEC), Sit to Stand, Step Quick Turn to the right, and Timed Walk indicated a significant change from post-balance intervention to follow-up test. There was an improvement on the Timed Walk performance and the standing on the foam with the eyes closed performance. There was a decline in performance on the sit-to-stand, step quick turn to the right, and the standing on the firm surface with the eyes open. The participants had an increase on

the FIEO, which could be because they progressed to harder exercises once this one was easy for them. Because they were no longer practicing this exercise, their performance may have been negatively impacted. Also, some of the participants talked during this test, which could have caused them to move. The participants did practice exercises standing on a piece of foam, which could be why the FOEC sway decreased from post-intervention to follow-up test. There was an increase on FOEC sway from pre-test to post-test. There could have been an improvement on standing on the foam from post-intervention to follow-up because the participants were able to use the foam (each participant was given one at the end of the balance intervention). The participants were able to train on an unstable surface which helped to facilitate proprioception by the skin receptors in the soles of the feet, but also the mechanoreceptors in the muscles and joints (Hirase, 2015). Other studies have shown that using an unstable surface results in increases in balance and improves physical functioning with a lower number of exercise sessions (Hirase, 2015). The participants in the balance training intervention did not use the foam during the entire six-week intervention, so they did not practice on it the whole time prior to post-testing. However, they had the foam available for practice during the entire follow-up period.

- The participants had a significantly large increase in turn sway on the right side on the Step Quick Turn to the right. This could be due to the fact that training resulted in greater confidence and subsequently, a faster turn time. It is possible that the faster turn time may have caused more sway when they turned.

- The SQT was a hard test for most participants to perform because they had a hard time doing the pivot turn, so because of this, they performed the test very slowly at times to make sure they took the right steps. This would affect their turn time and possibly their turn sway.
- There was a slight increase in sway on the STS from post-test to follow-up test and that could be because some of the participants had a hard time standing up and standing still right after standing up. The participants may have had a hard time standing still when they stood up because their normal compensations were taken away during testing and they could not rely on these.
- The participants improved their time on the Timed Walk from post-test to follow-up test. The participants were told to walk at a speed they would walk if they were outside at a stop light each time they did the Timed Walk test. Participants may have been getting more physical activity because of the continued participation in the balance exercises. However, some of the participants said this was the only exercise they continued during the follow-up period, so they continued walking for the 12-week intervention and follow-up periods, which made walking easier for them after doing the exercise for 12 weeks.

RQ5: Does fear of falling decrease from post-test to follow-up assessment?

H_R5: Fear of falling of participants of a 6-week behavioral intervention will be lower at follow-up assessment than those who did not participate in the intervention.

The null hypothesis was retained for research question number five in relation to the Falls Efficacy Scale scores. FES scores stayed the same over the six-week follow-up period indicating that there was not an increase in fear of falling. Comparison of the FES scores from post-balance intervention to follow-up test indicated no significant difference between those who received a behavioral intervention compared to the control group; however, this is good because it means that both groups maintained confidence that they would not fall. A possible explanation is that the participants in the intervention group had a lower average score (low fear of falling) at pre- and post-test than the control group, so there may have been a ceiling effect that limited outr ability to measure change. The lowest possible FES score is a 10 and the mean of the intervention group was a 12.5 at post-test. This means that most of the participants scored very low, indicating that they did not have a fear of falling. Lastly, the participants could have felt like they improved enough from pre- to post-test, that even though they did the balance exercises on their own, they did not feel like they were any more confident than they were at post- test. Overall, the participants fear of falling did not change over time, which means that they were able to maintain a higher self-efficacy related to their ability to carry out activities of daily living without falling, which was the goal of the intervention.

Significance of Results

The results from this study show that balance exercises improved some balance measures and decreased fear of falling after a 6-week balance training intervention. There were no statistically significant improvements on some of the laboratory measures of balance (mCTSIB, STS, and SUO) and one of the functional measures of balance (TUG) from pre-test to post-test. There were statistically significant improvements from pre-test to post-test in one laboratory balance measure (SQT), a functional measure of balance (TiW), and fear of falling (FES). There were no statistically significant improvements on some of the laboratory balance measures (FIEC, FOEO, TaW, and SUO), one functional measure of balance (TUG), and fear of falling (FES) from post-test to follow-up test. From a function standpoint, this is a positive outcome since these findings indicate maintenance of performance on a number of the balance measures. In older adults, such as those in this study, prevention of declines in function is a positive intervention outcome. There were statistically significant improvements in some laboratory balance measures (FIEO, FOEC, SQT, STS) and one functional balance measure (TiW) from post-intervention to follow-up test. The results indicate that the participants were able to maintain their balance and function after 12 weeks. This is important because of the fact that this was an older population. Older adults tend to have a harder time maintaining any gains or even avoiding declines in function (Manini, 2009), but this group was able to maintain over time. The participants felt more confident in carrying out the tasks that were given to them. There was a decrease in sway over time while completing several of the measurement tasks, which could be because participants improved ankle and leg strength during the intervention.

While some of the literature on balance interventions demonstrated a variety of health benefits for older adults, many studies lacked the evidence from controlled studies (Bulat, 2007; Seidler, 1997). The results for the balance measures assessed by the NeuroCom Balance Master® seem to be contradictory with results from previous literature, but again that could be due to the fact that the NeuroCom Balance Master® is a very sensitive test compared to functional measures of balance used in other studies because it actually takes into account participants sway while completing a task. The Berg Balance Scale (BBS) is a functional measure of balance that is used often with older adults, but tends to have a ceiling effect. The studies that show improvements on the BBS are studies that use participants who have poor balance based on a low score at pre-test (Steadman, 2003). It should be noted that there were not balance exercises incorporated into the training intervention that duplicated the movements for some of the NeuroCom Balance Master testing maneuvers. Also, the NeuroCom Balance Master testing protocols are very specific in terms of foot and hand positioning during testing. This negated the ability of participants to use their normal compensatory mechanisms used to help improve stability (i.e., shifting of hands, arms, and feet to improve balance).

Many of the participants noted that they felt more confident in their balance and in being able to perform daily activities without falling. The training could have resulted to a false confidence among the participants, meaning they felt more confident even though their balance measures did not show a significant improvement over time. This could actually lead to an increase risk of falls if participants feel more confident and and attempt to perform tasks that are riskier. One way to possibly lower the negative effect might be to add in an education component into the intervention that can be tested. Education can provide: (1) awareness to older adults about the problems with an increased risk of falls, (2) information about how to lower the risk of falls the proper way and the proper ways to stay safe at an older age, even if they feel like they are able to do everything normal. Even though the participants feel more confident, it does not necessarily mean their balance is better or that they are at a lower risk of falls. The only way to say they are at a lower risk of falls is to see a significant decrease in postural sway on the balance measures, which this study did not find for many of the measures used.

Most studies that have shown beneficial effects from balance training for older adults are based only on pre- to post-intervention analysis (Bulat, 2007; Means, 2005). Varied results from different studies may result from the use of different instruments/measures to assess outcome variables, different duration of interventions, different balance exercises, and different research designs. These things could be reasons for why there were non-significant changes following a 6-week balance training intervention for these older adults. Even though the intervention group had significantly more minutes of exercise, there might be different ways to engage with the older adults to get them to continue doing more of the balance exercises. One suggestion might be to have more face to face meetings during the behavioral intervention, rather than only email and phone calls. This might help because the participants actually see you and they might feel more comfortable to tell you the truth, ask questions or raise any concerns.

Strengths

This study had several strengths. The strengths of this study are:

- Use of a real-life setting for the intervention, which was done at an independent living center, where most of the participants were living. The use of this setting helps to evaluate the efficacy of balance training outside of the controlled laboratory environment.
- Use of a control group for the balance intervention and for the behavioral intervention, which minimized threats to internal validity.
- Use of an advanced age group because many of the studies with older adults are 65 and up, whereas this study had the majority of participants between 75-90 years.

Limitations

This study had several limitations. The limitations of this study are:

- Use of convenient sampling for recruitment of participants. This resulted in inclusion of individuals from two separate independent living communities. Because of this, there was no way to assure that exposure to outside activities was equivalent for the two groups.
- Small sample size, especially for the control group, which may have reduced the power of between group analyses
- Generalizability is limited to a population that is predominantly female and Caucasian, the primary demographic characteristics of this sample. There were only a few males that participated in this study.
- Generalizability is limited to individuals 70 years and older because of the age range of study participants.

- Duration of intervention may have effected study outcomes. Although the total number of minutes of training was consistent with previous literature, this intervention was conducted for fewer weeks than the interventions in most previously reported studies. Because of the older age of participants, they may need to participate for a longer time period in order to obtain the greatest benefit from balance training.
- Use of the test protocols of the NeuroCom Balance Master® may not capture functional improvements resulting from training program, since postural sway may not be the best measure of functional balance in this age group.
- Potential limitations of the accuracy of Falls Efficacy Scale score values. The form that was used stated a score that indicated a fear of falling. The presence of this information may have affected participant response when completing the questionnaire.
- Lack of randomization of groups. It was necessary to group participants based on the residential facility in which the program was offered. This could have led to threats to internal validity of the study
- Difficulty in recruiting participants for the control group, which resulted in a small sample size.
- Potential bias between groups based on some baseline differences in outcome measures
- Potential limitations due to memory loss. Many participants struggled to remember the exercises that they learned during the intervention, which could be a limitation.

The information gained from this research improves the understanding of the impact of balance training on balance and fear of falling in older adults. However, more research needs to be conducted to expand the understanding of the relationship between balance training and dynamic and static balance, fear of falling, and other outcome measures related to fall prevention.

Recommendations for Future Research

The existing literature shows mixed results related to the effects of balance training on balance and fear of falling in this age group. The results from this study are still inconsistent with the previous literature because of the type and duration of balance exercises, the variations in participant populations, and the choice of measurement tools used in the current versus previous studies. Therefore, there are still many questions left unanswered. It is recommended that future studies focus on these areas:

- Identification of the optimal duration and frequency of balance exercises. This study might suggest we need a larger dose for a longer period of time with the older adult population,
- Comparison of different age groups (old-old and young-old) for maturation changes with aging,
- Identify measurements for balance that are consistent with the outcomes for balance training,
- Use of larger, more diverse samples to assess if balance training is appropriate for all older adults,

- Comparison of NeuroCom Balance Master® to functional balance measures to identify if postural sway is an adequate measure of balance,
- Identification of the best balance exercises for older adults to help improve balance and physical function,
- Identification of proper ways to teach older adults balance exercises so that they remember them because of potential loss of memory issues,
- Assessment of the use of prompts delivered by a cell phone to see if they are effective and a convenient way to increase physical activity among older adults, and
- There were several people that dropped out of this study due to previous injuries. It would be ideal to find individuals that did not have any concerns before starting the intervention to make sure there are no drop outs.

Recommendations for Future Practice

The presumed health benefits of balance training have made it increasingly popular among older adults. Balance exercises are easy to do and can be done anywhere, with little to no equipment. There is evidence from previous literature of the positive effects of balance training on balance, fear of falling, physical function, and fall prevention in older adults (Gusi, 2012; Seidler, 1997). The mixed study results and observations from the current study can be used to inform balance training programs in the following ways:

- Identification of the right setting for a balance training intervention with the best duration of the intervention is critical in terms of making global recommendations. Holding the intervention at an independent living center makes it readily accessible for people that live there. It might be more difficult for people that do not live at the center to participate, especially if the center does not allow outside people to come in for exercise classes. A community center or a local gym that have public access may be a better location because everyone can access such a facility.

- Determination of the right dose and length of the intervention for older adults is critical. It may be more beneficial to have a longer intervention, like 12 weeks versus six weeks intervention even if the total dose of exercise remains constant. This study utilized one hour classes conducted three times a week for six weeks. It is important to determine whether this is the optimum dose/frequency for conducting balance training programs.
- It may be important to train the older adults in the development of compensatory mechanisms that can help them maintain their postural stability. It also is important to assure that training exercises incorporate the movements/tasks that are integrated into testing procedures.
- Balance exercises should be included in exercises prescribed for older adults in a therapeutic setting such as in physical therapy. It would be good for older adults to continue practice of these exercises at a different location after therapy. It may be helpful to work with physical therapists or other healthcare practitioners to establish a training protocol that includes the best balance exercises.
- The balance exercises should include exercises that challenge the participant's vestibular system, proprioception, strength, and vision. These are the main components of good balance, so they should be challenged. Many of the exercises

done in this intervention challenged these components, so they could all be incorporated.

- Inclusion of health education classes with the balance training for a minimum of one time a week during the intervention. Pamphlets were given to participants during the balance intervention, however, the effectiveness of these educational activities was not assessed. Identification of information related to challenges older adults may face when continuing balance exercises, strategies on how to overcome those challenges, and best places to practice the exercises might aid in preparing participants to adhere to the program guidelines even after a structured program has ended.
- Motivation for continuing to exercise following the intervention should include a balance exercise manual, so the participants can see all of the exercises that they are supposed to perform. Also, this should be done to make sure practitioners are encouraging their patients to continue to exercise because it helps to prevent falls, function better, and to live independently longer.

It would be easy to incorporate balance exercises into health promotion programs in different settings. It would be important to find the best exercises that focus on dynamic and static balance, lower body strength, and physical function. Duration and dose (amount of time practiced) were not consistent in previous literature, which made it difficult to identify the best duration and dose for the current study in order to achieve the maximum results.

Summary

In summary, the findings from this study indicate that participation in a 6-week balance training intervention can improve some balance measures and reduce fear of falling significantly in community-dwelling older adults over 70 years. Balance training has advantages of low cost and an easy training activity that is suggested for older adults for preventing falls (Lesinski, 2015). Results from this study add to the growing body of literature on the beneficial effects of balance training for fall prevention in older adults. Future research is advised to find the most beneficial balance exercises and the most appropriate duration and dose for older adults. Future research is also advised to find the best balance assessments for measuring the effects of balance training in this age group. With regards to behavioral interventions, practitioners should consider using cell phones as a way to communicate with, and deliver reminders and instructional prompts to their clients.

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Appendix A: Institutional Review Board Approval Letter

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Initial Submission – Expedited Review – AP01

Date: November 10, 2016

IRB#: 7311

Principal Investigator: Kristin Bogda

Approval Date: 11/09/2016
Expiration Date: 10/31/2017

Study Title: The Effects of Balance Training on Balance, Strength, Physical Functional Performance, Fear of Falling, and Fall Prevention Knowledge in Older Adults

Expedited Category: Category 4

Collection/Use of PHI: No

On behalf of the Institutional Review Board (IRB), I have reviewed and granted expedited approval of the above-referenced research study. To view the documents approved for this submission, open this study from the *My Studies* option, go to *Submission History*, go to *Completed Submissions* tab and then click the *Details* icon.

As principal investigator of this research study, you are responsible to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Obtain informed consent and research privacy authorization using the currently approved, stamped forms and retain all original, signed forms, if applicable.
- Request approval from the IRB prior to implementing any/all modifications.
- Promptly report to the IRB any harm experienced by a participant that is both unanticipated and related per IRB policy.
- Maintain accurate and complete study records for evaluation by the HRPP Quality Improvement Program and, if applicable, inspection by regulatory agencies and/or the study sponsor.
- Promptly submit continuing review documents to the IRB upon notification approximately 60 days prior to the expiration date indicated above.
- Submit a final closure report at the completion of the project.

If you have questions about this notification or using iRIS, contact the IRB @ 405-325-8110 or irb@ou.edu.

Cordially,

Aimee Franklin

Aimee Franklin, Ph.D.
Chair, Institutional Review Board

Appendix B: Recruitment Announcement

<u>Recruitment Flyer</u>

Are you a healthy adult over the age of 60 years?

Are you interested in participating in a research study that looks at the effects of balance training on balance and fear of falling.

If you volunteer to participate, you will be asked to complete a couple of questionnaires and a series of activities that will evaluate your balance and your confidence in performing daily activities. Testing will take place at the University of Oklahoma campus and will take 1-1 ½ hours per testing session and you will come in for three separate testing sessions, for a total time commitment of 3-5 hours for testing. Balance training classes will take place at Silver Elm Estates Norman for the intervention group and at Southwest Mansions for the control group and will last 6 weeks where you will meet 3 times a week for 60-minute classes.

If you are interested, please contact:
Kristin Bogda
k.bogda@ou.edu
Department of Health and Exercise Science
405-325-1372

<u>The University of Oklahoma is an equal opportunity institution</u>

Appendix C: Eligibility Survey

Eligibility Criteria Form

Name ________________________

Inclusion criteria (circle Y or N)

Y **N** 1**.** Age over 60 years

Y **N** 2**.** Are ambulatory

Y **N** 3**.** Able to practice balance exercises on your own

Exclusion Criteria:

Y **N** 1. Have a physical condition that would make walking difficult/not possible

Y **N** 2. **H**ave a condition that will affect participation

Y **N** 3. Not a resident of specific residential communities

Appendix D: Informed Consent Form

Signed Consent to Participate in Research

Would you like to be involved in research at the University of Oklahoma?

I am Kristin Bogda from the Health and Exercise Science Department and I invite you to participate in my research project entitled **The Effects of Balance Training on Balance and Fear of Falling in Older Adults**. This research is being conducted at the University of Oklahoma, Silver Elm Estates Norman, and Rambling Oaks Assisted Living. You were selected as a possible participant because you are a healthy adult over the age of 60 years.

Please read this document and ask any questions that you may have BEFORE agreeing to take part in my research.

What is the purpose of this research? The purpose of this research is to evaluate the effects of a balance training intervention on balance and fear of falling in older adults.

How many participants will be in this research? About 60 people will take part in this research.

What will I be asked to do? If you agree to be in this research, you will participate in a balance training intervention and you will be asked to do some or all of the following:

Participate in three testing sessions that will be conducted in the Department of Health and Exercise Science on the University of Oklahoma campus and will include:

- Performing a series of tasks on the NeuroCom Balance Master (a flat device that lies on the floor that measures how much you sway (a measure of balance) while performing activities like standing on one leg, standing on foam, turning, walking heel-to-toe, and stepping up and over a curb. All balance tests will be closely monitored with at least 1 spotter to guard against falls.
- Performing the Timed Up and Go test that requires you to stand up from a chair and walk around a cone 3 meters away and sitting back down in the chair.
- Performing a Timed Walk test that requires you to walk the distance of sidewalk to sidewalk across two lanes of traffic. This path will be marked on the floor inside and you will be timed to walk that distance.
- Completing a couple of questionnaires about general health status and confidence in performing daily activities.

Participate in a balance training intervention and an adherence intervention which will take place at Silver Elm Estates Norman, or a control group which will receive balance training at Rambling Oaks Assisted Living and include:

- Balance training intervention: You will be assigned to an intervention or a control group. The control group will be asked to maintain normal activity for the first six weeks. The control group will be provided the balance training intervention after the completion of the first intervention phase. The intervention group will meet three times a week for six weeks for 60-minute classes. Each class will consist of a warm up, balance exercises, and a cool down. The warm up will last for 10 minutes and will include walking and stretching in order to bring the heart rate up and to warm up the muscles. The balance exercises will be individualized for each of you based on your ability. The exercises will be completed three times each for at least 15 seconds. In order to increase safety there will be a chair in front of each of you to be used to stabilize your body during movement and/or you will be paired up with another participant so you can spot each other. The exercises will be practiced on the firm surface during the initial phase of the program and you will progress to practicing certain exercises on a pliable surface such as foam, if you are stable enough to do so. All exercises will be practiced with the eyes open to begin with, but will progress to being practiced with the eyes closed. Some of you may progress to practicing balance exercises while multitasking. The balance exercises include: calf raises, standing with feet together, standing on one foot, sit-to-stand, tandem stand, hip raise, hip extension, knee bend, tandem walking, lateral reaching, turning 360°, walking on toes, talking on heels, walking sideways, walking backwards, reach for an object on the ground, reaching for an object from up high, standing with feet together and throwing a ball back and forth with a partner, standing on one foot and throwing a ball back and forth with a partner, standing with feet together on a foam pad or air disc, and standing on one foot on foam pad or air disc. The cool down will be 10 minutes long where you will stretch all major muscle groups. Each stretch will be held for 30 seconds and completed three times.

- Education Intervention: Participants in the balance training intervention will also receive an education component. There will be 6 topics, with one topic assigned per week. Each of you will receive a brochure about the topic to take home after it is discussed in class. This will be discussed while the you are stretching and cooling down. The topics include: fall prevention importance, risks and causes of falls, how to get up from a fall, home safety importance, home modifications that can be made, and other exercises that can help prevent falls.

- Adherence Follow-up: after completion of the balance training program, you will be asked to continue your balance exercise on your own for another 6-week period. You also will be asked keep a weekly exercise adherence log to keep track of how many exercises you complete and how much time you spend on them. There will also be a weekly falls log kept where you will keep track of the number of falls and the factors that you think contributed to the fall. After this 6 weeks, you will be tested again.

How long will this take? Your participation will take approximately 1-1 ½ hours for each testing session (3-5 total hours for testing). The time for each balance training session will be approximately 1 hour, 3 times a week, for 6 weeks total (18 total hours for balance training).

What are the risks and/or benefits if I participate? Sometimes, when timed activities are carried out, there is the possibility that you may push yourself beyond your "normal" activity level, and as a result, you may experience temporary muscle fatigue and soreness. However, all testing activities are self-paced, so you can control both the time taken to complete tasks and the amount of weight that is lifted or the intensity of activity during tasks that include lifting and carrying activities. There also is the possibility that you could lose your balance and fall while doing the balance/physical function tasks. In order to reduce this risk, a person will serve as a spotter during all testing sessions.

You may experience temporary muscle fatigue and soreness at first because you might push yourself beyond your "normal" activity level. All balance exercises will be self-paced, so you can control the amount of time it takes to complete them. There is also the possibility that you could lose your balance and fall while doing the balance exercises. In order to reduce this risk, a chair will be placed in front of you to stabilize you during movements.

Benefits of participating in the balance training include possible maintenance or improvements in balance, possible improved confidence in the ability to do daily activities on your own, possibly be able to do daily activities easier, and improved fall prevention knowledge.

You will receive feedback related to their balance and physical functional fitness upon request at the completion of the study if you want this information.

What do I do if I am injured? If you are injured during your participation, report this to a researcher immediately. Emergency medical treatment is available. However, you or your insurance company will be expected to pay the usual charge from this treatment. The University of Oklahoma Norman Campus has set aside no funds to compensate you in the event of injury.

Will I be compensated for participating? You will not be reimbursed for your time and participation in this research.

Who will see my information? In research reports, there will be no information that will make it possible to identify you. Research records will be stored securely and only approved researchers and the OU Institution Review Board will have access to the records.

You have the right to access the research data that has been collected about you as a part of this research. However, you may not have access to this information until the entire research has been completed and you consent to this temporary restriction.

Do I have to participate? No. If you do not participate, you will not be penalized or lose benefits or services unrelated to the research. If you decide to participate, you can decline to answer any question and/or participate in study activities, and you can stop participating at any time.

Will my identity be anonymous or confidential? Your name and an ID# will be used to link with your responses from the different testing sessions. However, only approved researchers will have access to this information. The data you provide will be retained in anonymous form (by ID number only) after the study is completed unless you give me permission to retain your contact information at the end of the research. Please check all of the options that you agree to:

I agree for the researcher to retain my contact information at the end of the study. __Yes __No

I agree for the researcher to use my data in future studies. ___Yes ___ No

Photographing of Research Participants/Activities In order to preserve an image related to the research and your participation in the balance training program, photographs may be taken of participants. You have the right to refuse to allow photographs to be taken without penalty. Please select one of the following options:

I consent to photographs. ___ Yes ___ No

Will I be contacted again? The researcher may like to contact you again to recruit you into another research study or to gather additional information.

_____ I give my permission for the researcher to contact me in the future.

_____ I do not wish to be contacted by the researcher again.

Who do I contact with questions, concerns or complaints? If you have questions, concerns or complaints about the research or have experienced a research-related injury, contact me at (405) 325-1372 or k.bogda@ou.edu. You may also contact Dr. Laurette Taylor, graduate advisor, at (405) 325-5211 or at eltaylor@ou.edu. Contact the researcher(s) if you have questions, or if you have experienced a research-related injury.

You can also contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu if you have questions about your rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than the researcher(s) or if you cannot reach the researcher(s).

You will be given a copy of this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research*.*

Participant Signature	Print Name	Date
Signature of Researcher Obtaining Consent	Print Name	Date
Signature of Witness (if applicable)	Print Name	Date

Appendix E: Medical Clearance Form

Department of Health and Exercise Science - University of Oklahoma-Norman Campus

The Effects of Balance Training on Balance and Fear of Falling in Older Adults

MEDICAL CLEARANCE FORM

To the Attending Physician of: _______________________________

This individual wishes to participate in a research study investigating the impact of participation in a balance training program on balance. This project has been approved by the Institutional Review Board at the University of Oklahoma.

Description of the Study: Participants will be assigned to the intervention (balance training) group or the control group. Participants will be tested pre-, mid- and post-balance training intervention. Testing will involve completion of (1) several questionnaires, (2) 6 tasks that are designed to evaluate standing and moving balance, (3) the timed up and go test, and (4) a timed walk. All tests will be conducted in the Department of Health and Exercise Science at the University of Oklahoma.

Balance Training Intervention: Balance training will take place at Silver Elm Estates Norman for the intervention group and at Rambling Oaks Assisted Living for the control group. Participants will be assigned to an intervention or a control group. The control group will be asked to maintain normal activity for the first six weeks. The intervention group will meet three times a week for six weeks for 60-minute classes. Each class will consist of a warm up, balance exercises, and a cool down. The warm up will last for 10 minutes and will include walking and stretching in order to bring the heart rate up and to warm up the muscles. The balance exercises include: calf raises, standing with feet together, standing on one foot, sit-to-stand, tandem stand, hip raise, hip extension, knee bend, tandem walking, lateral reaching, turning 360°, walking on toes, walking on heels, walking sideways, walking backwards, reach for an object on the ground, reaching for an object from up high, standing with feet together and throwing a ball back and forth with a partner, standing on one foot and throwing a ball back and forth with a partner, standing with feet together on a foam pad or air disc, and standing on one foot on a foam pad or air disc. The balance exercises will be individualized for each participant based on their ability. The exercises will be completed three times each for at least 15 seconds. In order to increase safety, there will be a chair in front of each participant to be used to stabilize the body during movement and/or the participant will be paired with another participant so that they can spot each other. The exercises will be practiced on the firm surface during the initial phase of the program and will progress to practicing certain exercises on a pliable surface such as foam if the participant is stable enough to do so. All exercises will be practiced with the eyes open to begin with, but will progress to being practiced with the eyes closed. Some participants may progress to practicing balance exercises while multitasking. The cool down will be 10 minutes long where participants will stretch all major muscle groups. Each stretch will be held for 30 seconds and completed three times. The control group will receive this same intervention during Phase 2.

Education Intervention: Participants in the balance training intervention will also receive an education component. There will be 6 topics, with one topic assigned per week. Each participant will receive a flyer about the topic to take home after it is discussed in class. This will be discussed while the participants are stretching and cooling down. The topics include: importance of fall prevention, risks and causes of falls, how to get up from a fall, home safety importance, home modifications that can be made, and other exercises that can help prevent falls.

Adherence Intervention: Participants in the intervention group will be randomly assigned to the adherence intervention or as an adherence control. The adherence intervention that will assess maintenance of balance training without supervision will be implemented after completion of the 6-week supervised balance training program (Phase 2). During the adherence intervention, participants will receive one email each week, a biweekly phone call, and a text message (or other messaging app such as Messenger) each week for those with a cell phone. The email, text message, and phone call will provide reminders, inspirational messages, and verbal reinforcements. Participants will keep a weekly exercise adherence log to keep track of how many exercises they complete and how much time they spend on them. There will also be a weekly falls log kept where participants will keep track of the number of falls and the factors that they think contributed to the fall. During this same period, adherence controls will be given a booklet or video of the exercises and asked to continue doing the balance exercise on their own. All participants (adherence intervention or adherence control) will be tested again after Phase 2.

Performance-Based Measures of Balance and Sway: **The NeuroCom BalanceMaster®** will be used to assess balance and sway. The protocols are broken down into two categories, Impairment (standing still) and Functional (moving), depending on the aspect of balance the test measures. Balance measures will be taken while performing 4 tasks on a force platform (measures changes in surface pressure and force due to body movement). All balance tests will be closely monitored with at least 1 spotter to guard against falls. The balance tests include:

a. **Modified CTSIB (mCTSIB)** – quantifies postural sway with the participant standing quietly on the forceplate, for multiple 10 second trials. **The mCTSIB Conditions:** The mCTSIB consists of three trials of 2 conditions: (1) eyes closed [EC] standing on a firm surface, and (2) EC standing on a foam surface
b. **Unilateral Stance (US)** – quantifies postural sway with the subject standing quietly on one foot on the forceplate, with eyes open and closed. **US Conditions:** The US consists of four conditions, each consisting of three trials, normally conducted in the following order: (1) EO left, (2) EO right, (3) EC left, (4) EC right
c. **Sit-to-Stand (STS)** – quantifies postural sway as the subject rises from a seated to a standing position. **Sit-to-Stand Conditions**. Three trials were performed in which the subject sits on a wooden box and then stands up as quickly as possible when cued.
d. **Step/Quick Turn (SQT)** – quantifies turn sway as the subject takes two forward steps, quickly turns 180 degrees, and steps back to the start location. **Step/Quick Turn Conditions**: The SQT assessment consists of three trials of both conditions: left foot first and right foot first.
e. **Tandem Walk (Steinberg et al.)** - quantifies postural sway and characteristics of gait as the participants "walks a tightrope" from one end of the forceplate to the other. **Tandem Walk Conditions**: The TW assessment consists of three trials and will measure step width, speed, and endpoint sway velocity.
f. **Step-Up-and-Over (SUO)**- quantifies postural sway as the participant steps up onto a curb with one foot, lifts the other foot over the curb and down onto the floor, and then steps down with the foot that was placed on the curb. **Step-Up-and-Over Conditions**: The SUO assessment consists of three trials and will measure end sway.

Timed Walk: The participant will be timed while walking on a path that mimics a two lane street and is the distance of sidewalk to sidewalk.

Timed Up & Go Test: The participant will stand up from a chair, walk 3 meters, turn, walk back to the chair, and sit down. Participants will complete this three times.

Sometimes, when timed activities are carried out, there is the possibility that participants may push themselves beyond their "normal" activity level, and as a result, experience temporary muscle fatigue and soreness. However, all testing activities are self-paced, so the subject can control both the time taken to complete tasks and the amount of weight that is lifted during tasks that include lifting and carrying activities. The tester will inform the subject that he/she can rest between tasks if desired and safety precautions (use of spotters and transfer belts) will be used minimize the possibility of fall during performance of the testing tasks.

Please check one of the following conditions.

_____ To my knowledge, there is no reason why this patient, _______________________should not be allowed to participate in this study. I recommend that he/she be allowed to participate in the study

_____ I recommend that this patient, _________________________, **should not** be allowed to participate in the study.

Does this patient take medication that can make him/her more vulnerable to falling? YES ______ NO _______

If yes, please list:

____

_________________________________ ______________
Physician's Signature Date

If you have any questions about this form, please contact:

E. Laurette Taylor, Ph.D.,
Associate Professor and Director
of The Functional Assessment
Laboratory
405-325-5211
Or
Kristin Bogda
k.bogda@ou.edu, 314-952-6372

Appendix F: HIPPA Form

AUTHORIZATION TO USE or SHARE

HEALTH INFORMATION[1] THAT IDENTIFIES YOU FOR

RESEARCH

An Informed Consent Document for Research Participation may also be required.

Title of Research Project: **The Effects of Balance Training on Balance and Fear of Falling in Older Adults**

IRB Number: 7311

Leader of Research Team: Kristin Bogda
Address: The University of Oklahoma
Department of Health and Exercise Science
1401 Asp Avenue
Norman, OK 73019

Phone Number**: (**314) 952-6372
If you decide to sign this document, University of Oklahoma (OU) researchers may use or share information that identifies you (protected health information) for their research. Protected health information will be called PHI in this document.

PHI To Be Used or Shared. Federal law requires that researchers get your permission (authorization) to use or share your PHI. If you give permission, the researchers may use or share with the people identified in this Authorization any PHI related to this research from your medical records and from any test results. Information used or shared may include all information relating to any tests, procedures, surveys, or interviews as outlined in the consent form; name, address, telephone number, date of birth, race, and government-issued identification numbers.

Purposes for Using or Sharing PHI. If you give permission, the researchers may use your PHI to answer and/or guide new research questions that may be part of future research projects.

Other Use and Sharing of PHI. If you give permission, the researchers may also use your PHI to develop new procedures or commercial products. They may share your PHI with other researchers, the research sponsor and its agents, the OU Institutional Review Board, auditors and inspectors who check the research, and government agencies such as the Department of Health and Human Services (HHS), and when required by law. The researchers may also share your PHI with all researchers working on this project and the faculty advisor.

[1] **Protected Health Information includes all identifiable information relating to any aspect of an individual's health whether past, present or future, created or maintained by a Covered Entity.**

<u>Confidentiality</u>. Although the researchers may report their findings in scientific journals or meetings, they will not identify you in their reports. The researchers will try to keep your information confidential, but confidentiality is not guaranteed. The law does not require everyone receiving the information covered by this document to keep it confidential, so they could release it to others, and federal law may no longer protect it.

YOU UNDERSTAND THAT YOUR PROTECTED HEALTH INFORMATION MAY INCLUDE INFORMATION REGARDING A COMMUNICABLE OR NONCOMMUNICABLE DISEASE.

<u>Voluntary Choice</u>. The choice to give OU researchers permission to use or share your PHI for their research is voluntary. It is completely up to you. No one can force you to give permission. However, you must give permission for OU researchers to use or share your PHI if you want to participate in the research and, if you cancel your authorization, you can no longer participate in this study.

Refusing to give permission will not affect your ability to get routine treatment or health care unrelated to this study from OU.

<u>Canceling Permission</u>. If you give the OU researchers permission to use or share your PHI, you have a right to cancel your permission whenever you want. However, canceling your permission will not apply to information that the researchers have already used, relied on, or shared or to information necessary to maintain the reliability or integrity of this research.

<u>End of Permission.</u> Unless you cancel it, permission for OU researchers to use or share your PHI for their research will <u>never end.</u>

<u>Contacting OU</u>: You may find out if your PHI has been shared, get a copy of your PHI, or cancel your permission at any time by writing to:

Privacy Official	or	Privacy Board
University of Oklahoma		University of Oklahoma
PO Box 26901		201 Stephenson Pkwy, Suite 4300A
Oklahoma City, OK 73190		Norman, OK 73019

If you have questions, call: (405) 271-2511 or (405) 325-8110

<u>Access to Information.</u> You have the right to access the medical information that has been collected about you as a part of this research study. However, you may not have access to this medical information until the entire research study is completely finished. You consent to this temporary restriction.

<u>Giving Permission</u>. By signing this form, you give OU and OU's researchers led by the Research Team Leader permission to share your PHI for the research project listed at the top of this form.

Participant Name (Print): ____

Signature of Participant Date
or Parent if Participant is a minor

Or

Signature of Legal Representative** Date

**If signed by a Legal Representative of the Participant, provide a description of the relationship to the Participant and the authority to act as Legal Representative:

OU may ask you to produce evidence of your relationship.

A signed copy of this form must be given to the Participant or the Legal Representative at the time this signed form is provided to the researcher or his representative.

Appendix G: Contact Information Form

Contact Information Form

Contact Information:

Please complete the following information. This information will stored separately from all research data and will only be used to contact you about research related activities. All contact information will be destroyed at the end of the study.

Name: ______________________________________ Date:__________________

Phone: _____________________ Email:_____________________________

Primary Care / Physician (Name):___________________________
Phone:________________

Emergency Contact (Name):________________________________
Phone:________________

Appendix H: Demographic Information Form

Demographic Information Form

1. What is your age? _____ (years)

2. What is your gender? ________ (M/F)

3. What is your marital status?
   - Married
   - Separated
   - Divorced
   - Widowed
   - Single / Never Married

4. What would you perceive to be your ethnicity? ____________________

5. What is the highest level of education you have completed?
   - Never attended school
   - Elementary school (Grades 1-8)
   - Some high-school (Grades 9-11)
   - High school diploma (Grades 12-GED)
   - College or University diploma (College 1 year to 3 years)
   - Graduate or professional degree (College 4 years or more)

6. Which of the following best describes your current employment status?
   - Employed full time
   - Employed part-time
   - Home duties
   - Unemployed
   - Full time student
   - Part-time student
   - Retired
   - Permanently ill/ unable to work

7. Which of the following categories does your total gross annual household income from all sources fall into? That is the total income from all members of your household before tax is deducted:
   - Less than $10,000
   - $10,001 - $20,000
   - $20,001 - $40,000
   - $40,001 - $60,000
   - $60,001 - $80,000
   - Over $80,000
   - Don’t know

Appendix I: Medical Outcomes Survey

Medical Outcomes Study: 36-Item Short Form Survey Instrument

RAND 36-Item Health Survey 1.0 Questionnaire Items

1. In general, would you say your health is:	
Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

2. **Compared to one year ago**, how would your rate your health in general **now**?	
Much better now than one year ago	1
Somewhat better now than one year ago	2
About the same	3
Somewhat worse now than one year ago	4
Much worse now than one year ago	5

The following items are about activities you might do during a typical day. Does **your health now limit you** in these activities? If so, how much?

(Circle One Number on Each Line)

	Yes, Limited a Lot	Yes, Limited a Little	No, Not limited at All
3. **Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports	[1]	[2]	[3]
4. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	[1]	[2]	[3]
5. Lifting or carrying groceries	[1]	[2]	[3]

6. Climbing **several** flights of stairs	[1]	[2]	[3]
7. Climbing **one** flight of stairs	[1]	[2]	[3]
8. Bending, kneeling, or stooping	[1]	[2]	[3]
9. Walking **more than a mile**	[1]	[2]	[3]
10. Walking **several blocks**	[1]	[2]	[3]
11. Walking **one block**	[1]	[2]	[3]
12. Bathing or dressing yourself	[1]	[2]	[3]

During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities **as a result of your physical health**?

(Circle One Number on Each Line)

	Yes	No
13. Cut down the amount of time you spent on work or other activities	1	2
14. **Accomplished less** than you would like	1	2
15. Were limited in the **kind** of work or other activities	1	2
16. Had **difficulty** performing the work or other activities (for example, it took extra effort)	1	2

During the **past 4 weeks,** have you had any of the following problems with your work or other regular daily activities **as a result of any emotional problems** (such as feeling depressed or anxious)?

(Circle One Number on Each Line)

	Yes	No
17. Cut down the **amount of time** you spent on work or other activities	1	2
18. **Accomplished less** than you would like	1	2
19. Didn't do work or other activities as **carefully** as usual	1	2

20. During the **past 4 weeks,** to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

(Circle One Number)

Not at all 1

Slightly 2

Moderately 3

Quite a bit 4

Extremely 5

21. How much **bodily** pain have you had during the **past 4 weeks**?

(Circle One Number)

None 1

Very mild 2

Mild 3

Moderate 4

Severe 5

Very severe 6

22. During the **past 4 weeks,** how much did **pain** interfere with your normal work (including both work outside the home and housework)?

(Circle One Number)

Not at all 1

A little bit 2

Moderately 3

Quite a bit 4

Extremely 5

These questions are about how you feel and how things have been with you **during the past 4 weeks**. For each question, please give the one answer that comes closest to the way you have been feeling.

How much of the time during the **past 4 weeks** . . .

(Circle One Number on Each Line)

	All of the Time	Most of the Time	A Good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
23. Did you feel full of pep?	1	2	3	4	5	6
24. Have you been a very nervous person?	1	2	3	4	5	6
25. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
26. Have you felt calm and peaceful?	1	2	3	4	5	6
27. Did you have a lot of energy?	1	2	3	4	5	6
28. Have you felt downhearted and blue?	1	2	3	4	5	6
29. Did you feel worn out?	1	2	3	4	5	6
30. Have you been a happy person?	1	2	3	4	5	6
31. Did you feel tired?	1	2	3	4	5	6

32. During the **past 4 weeks,** how much of the time has your **physical health or emotional problems** interfered with your social activities (like visiting with friends, relatives, etc.)?

(Circle One Number)

All of the time 1

Most of the time 2

Some of the time 3

A little of the time 4

None of the time 5

How TRUE or FALSE is <u>each</u> of the following statements for you.

(Circle One Number on Each Line)

	Definitely True	Mostly True	Don't Know	Mostly False	Definitely False
33. I seem to get sick a little easier than other people	1	2	3	4	5
34. I am as healthy as anybody I know	1	2	3	4	5
35. I expect my health to get worse	1	2	3	4	5
36. My health is excellent	1	2	3	4	5

Appendix J: Falls Efficacy Scale

Falls Efficacy Scale

Name:_______________________________ Date:_______________

On a scale from 1 to 10, with 1 being very confident and 10 being not confident at all, how confident are you that you do the following activities without falling?

Activity:	**Score:** 1 = very confident 10 = not confident at all
Take a bath or shower	
Reach into cabinets or closets	
Walk around the house	
Prepare meals not requiring carrying heavy or hot objects	
Get in and out of bed	
Answer the door or telephone	
Get in and out of a chair	
Getting dressed and undressed	
Personal grooming (i.e. washing your face)	
Getting on and off of the toilet	
Total Score	

A total score of greater than 70 indicates that the person has a fear of falling

Adapted from Tinetti et al (1990)

Appendix K: Data Collection Form

Code #: ______________________________ Date: ___________________

	Trial 1	Trial 2	Trial 3
Timed Up and Go			
Timed Walk			

Appendix L: Exit Survey Questions

Exit Interview

1. Did you enjoy the program?

2. Were there any factors that might positively or negatively have influenced your engagement in the balance training program? For example, weather – please describe those factors.

3. Did you join any exercise groups during the program?

4. Did you read the emails on a regular basis? Did they help you? How?

5. How often did you do the balance exercises each week on your own?

6. Did you implement any fall prevention tips that were taught in the class into your lifestyle?
   - If so, what did you change?

7. In your opinion, what are the strengths of this program?

8. How would you suggest that we change the program to make it better?

9. Any other suggestions?

Appendix M: Balance Exercises Log

Balance Exercises Log

Study ID number ___________ Balance Exercises Data Sheet for Week ________

Make sure you fill out the table below every day. Record the time that you started your exercises and the time you ended the exercises. Write down the number of exercises that you completed. Record which exercises you completed each day.

Day	Time On (am/pm)	Time Off (am/pm)	Number of exercises	Specific exercises completed	Comments
1					
2					
3					
4					
5					
6					
7					

*If you do not do any exercises for a day just write “Did not complete exercises” in the “Comments” section.

*If you have questions, comments or concerns, please contact Kristin Bogda at 314-952-6372 or k.bogda@ou.edu or my faculty advisor Laurette Taylor at 405-325-5211 or eltaylor@ou.edu

Appendix N: Falls Log

Falls Log

Study ID number ___________ Falls Sheet for Week ________

Make sure you fill out the table below every day. Record the number of falls each day. Also report what factors you think contributed to the fall.

Day	Number of Falls	Contributing Factors	Comments
1			
2			
3			
4			
5			
6			
7			

*If you do not have a fall for a day just write "Did not fall" in the "Comments" section.
*If you have questions, comments or concerns, please contact Kristin Bogda at 314-952-6372 or k.bogda@ou.edu or my faculty advisor Laurette Taylor at 405-325-5211 or eltaylor@ou.edu

Appendix O: Behavioral Intervention Weekly Emails

Weekly Emails

Week 1

Hello ___________!

As part of the balance training program you are participating in, you will be receiving weekly emails from me. I hope you will be able to use the tips I include each week. Thank you so much for your participation! Just a reminder, don't forget to fill out your Balance Exercises and Falls Logs this week!

Weekly Tip: It can be helpful to set goals about choosing physical activity instead of another activity (like watching TV). An example would be to set a goal of substituting balance exercises for your least favorite show. It may be helpful to set a specific time and place each day that you are able to practice.

Please do not hesitate to contact me or my faculty advisor, Laurette Taylor at eltaylor@ou.edu or 405-325-5211 if you have questions or concerns. Have a great week!

Kristin Bogda

Week 2

Hello __________!

I hope your week went well last week. Make sure to turn in the Balance Exercises and Falls Log from last week. And just as a reminder, don't forget to fill out the Logs this week!

Weekly Tip: When watching the TV try standing up during advertisement breaks and do some exercises. You can get through your exercises during one show just by getting up and doing them during commercial breaks. This will also allow for you to take breaks in between sets of exercises. You can do it!

Please do not hesitate to contact me or my faculty advisor, Laurette Taylor at eltaylor@ou.edu or 405-325-5211 if you have questions or concerns. Have a great week!

Kristin Bogda

Week 3

Hello __________!

I hope your week went well last week. Make sure to turn in the Balance Exercises and Falls Log from last week. And just as a reminder, don't forget to fill out the Logs this week!

Weekly Tip: Remember to keep doing your balance exercises most days of the week. Keep on improving! Invite a friend or family member to join you in doing the exercises. It will give you someone to talk to. Who knows, it may become a routine for both of you!

Please do not hesitate to contact me or my faculty advisor, Laurette Taylor at eltaylor@ou.edu or 405-325-5211 if you have questions or concerns. Have a great week!

Kristin Bogda

Week 4

Hello __________!

I hope your week went well last week. Make sure to turn in the Balance Exercises and Falls Log from last week. And just as a reminder, don't forget to fill out the Logs this week!

Weekly Tip: You passed the half-way mark and are still working hard! When the weeks get difficult and you don't think you can finish, look at your past weeks and remember your best week yet. Keep doing the exercises no matter what!
When you are busy having fun with crafts or doing puzzles, try interrupting these activities by standing up to do balance exercises to take breaks. Make it a habit to break up your hobby by doing balance exercises.

Please do not hesitate to contact me or my faculty advisor, Laurette Taylor at eltaylor@ou.edu or 405-325-5211 if you have questions or concerns. Have a great week!

Kristin Bogda

Week 5

Hello __________!

I hope your week went well last week. Make sure to turn in the Balance Exercises and Falls Log from last week. And just as a reminder, don't forget to fill out the Logs this week!

Weekly Tip: Think ahead as this program nears its end. Schedule your balance exercises into your day and set goals to practice 3, 5, or even 10 days in a row. Don't compare your balance exercises to other people. Instead compare with yourself. Do better this week than you did last week. Do better today than you did yesterday! Choose a small reward to give yourself when you reach your goal for each day. The reward can be something that you go buy like that book you have been wanting to read or something that is free like a nice bubble bath. This will help to improve your confidence to do the exercises even more!

Please do not hesitate to contact me or my faculty advisor, Laurette Taylor at eltaylor@ou.edu or 405-325-5211 if you have questions or concerns. Have a great week!

Kristin Bogda

Week 6

Hello __________!

I hope your week went well last week. Make sure to turn in the Balance Exercises and Falls Log from last week. And just as a reminder, don't forget to fill out the Logs this week!

Weekly Tip: Although balance exercises are considered a great form of exercise for older people due to the movements being slow, any exercise program is difficult to begin and maintain. You are now starting your last week and you have accomplished something great. Even though you may or may not have achieved the goals you set in the beginning, you are still reading these emails which means you still care about your fitness journey. Again, I say, you have accomplished something great and I encourage you to continue your journey!

Please do not hesitate to contact me or my faculty advisor, Laurette Taylor at eltaylor@ou.edu or 405-325-5211 if you have questions or concerns. Have a great week! And again, thank you for your participation!

Kristin Bogda

Appendix P: Behavioral Intervention Weekly Phone Dialogue

Phone Call Dialogue

(Starting week 6 then every 2 weeks after that)

1. "How is the balance training going for you so far?"

2. "Do you have any struggles/successful strategies?"

3. –Briefly go over the concepts in the messages from the emails in the past 2 weeks.

4. –Motivational comment. For example: "You have done well so far… keep up the good work!"