5-1-2001

A Comparison of Eyes Open Versus Eyes Closed Balance Training

Cara Carpenter
Pacific University

Megan Stanford
Pacific University

Katie Putnam
Pacific University

Recommended Citation
http://commons.pacificu.edu/pt/161

This Capstone Project is brought to you for free and open access by the Theses, Dissertations and Capstone Projects at CommonKnowledge. It has been accepted for inclusion in School of Physical Therapy by an authorized administrator of CommonKnowledge. For more information, please contact CommonKnowledge@pacificu.edu.
A Comparison of Eyes Open Versus Eyes Closed Balance Training

Abstract
Background and purpose. Numerous researchers have investigated balance ability and the training of balance in the elderly. However, research in this area is lacking evidence regarding whether training balance with one's eyes closed is more efficient than training with eyes open. The purpose of this study was to determine if a significant difference exists between the balance abilities of elderly subjects who practiced balance activities with their eyes open and subjects who trained with their eyes closed. Methods. Sixteen subjects age 65 years and older were assessed for pre- and post-training balance ability using the Fast Evaluation of Mobility, Balance and Fear (FEMBAF). The training consisted of half-hour sessions, three times a week for four weeks. During each session subjects performed a circuit of 5 balance activities. Some of the subjects (n=6) performed the exercises with their eyes open while the other subjects (n=10) performed the exercises with their eyes closed. Results. There was no significant difference (p

Degree Type
Capstone Project

Rights
Terms of use for work posted in CommonKnowledge.

Comments
PT OA: Y
Copyright and terms of use

If you have downloaded this document directly from the web or from CommonKnowledge, see the “Rights” section on the previous page for the terms of use.

If you have received this document through an interlibrary loan/document delivery service, the following terms of use apply:

Copyright in this work is held by the author(s). You may download or print any portion of this document for personal use only, or for any use that is allowed by fair use (Title 17, §107 U.S.C.). Except for personal or fair use, you or your borrowing library may not reproduce, remix, republish, post, transmit, or distribute this document, or any portion thereof, without the permission of the copyright owner. [Note: If this document is licensed under a Creative Commons license (see “Rights” on the previous page) which allows broader usage rights, your use is governed by the terms of that license.]

Inquiries regarding further use of these materials should be addressed to: CommonKnowledge Rights, Pacific University Library, 2043 College Way, Forest Grove, OR 97116, (503) 352-7209. Email inquiries may be directed to: copyright@pacificu.edu

This capstone project is available at CommonKnowledge: http://commons.pacificu.edu/pt/161
NOTICE TO READERS

This work is not a peer-reviewed publication. The student author(s) of this work have made every effort to provide accurate information and to rely on authoritative sources in the completion of this work. However, neither the author(s) nor the faculty advisor(s) warrants the completeness, accuracy or usefulness of the information provided in this work. This work should not be considered authoritative or comprehensive in and of itself and the author(s) and advisor(s) disclaim all responsibility for the results obtained from use of the information contained in this work. Knowledge and practice change constantly, and readers are advised to confirm the information found in this work with other more current and/or comprehensive sources.

The student authors attest that this work is completely their original authorship and that no material in this work has been plagiarized, fabricated or incorrectly attributed.
A COMPARISON OF EYES OPEN VERSUS EYES CLOSED
BALANCE TRAINING

By
Cara Carpenter
Megan Stanford
Katie Putnam

Submitted to the faculty of the
School of Physical Therapy
Pacific University
Forest Grove, Oregon
in partial fulfillment of the requirements
for the degree of
Master of Science in Physical Therapy
May, 2001

Advisors:

Laurie Lundy-Ekman, PhD, PT

Katie Farrell, MS, PT, NCS, GCS
ABSTRACT

A Comparison of Eyes Closed Versus Eyes Open Balance Training

Cara Carpenter, Megan Stanford, Katie Putnam

Background and purpose. Numerous researchers have investigated balance ability and the training of balance in the elderly. However, research in this area is lacking evidence regarding whether training balance with one’s eyes closed is more efficient than training with eyes open. The purpose of this study was to determine if a significant difference exists between the balance abilities of elderly subjects who practiced balance activities with their eyes open and subjects who trained with their eyes closed. Methods. Sixteen subjects age 65 years and older were assessed for pre- and post-training balance ability using the Fast Evaluation of Mobility, Balance and Fear (FEMBAF). The training consisted of half-hour sessions, three times a week for four weeks. During each session subjects performed a circuit of 5 balance activities. Some of the subjects (n=6) performed the exercises with their eyes open while the other subjects (n=10) performed the exercises with their eyes closed. Results. There was no significant difference (p<0.05) between the eyes open and eyes closed group in the FEMBAF pre- and post-tests. There was, however, a significant improvement in overall FEMBAF scores for both groups. Conclusion and Discussion. This study did not support the hypothesis that training balance with eyes closed would be more beneficial than training with eyes open. The small population and ambiguity in the scoring of the FEMBAF may, in part, be responsible for these findings. The results of this study do support the idea that elderly adults can improve their balance in a relatively small number of training sessions.
ACKNOWLEDGEMENTS

We would like to thank Dr. Lundy-Ekman and Professor Farrell for their guidance and assistance in designing our study, answering countless questions, for editing our manuscripts, and for their encouragement. Our sincere appreciation goes to all of our subjects for volunteering their time to participate in our study. In addition, we are grateful to the Jennings-McCall Retirement Center and the Rosewood Retirement Center for allowing us to hold our testing and training sessions in their facilities.
List of Tables
Table Demographic Characteristics of Subjects 33

List of Figures
Figure Pre- & Post-Test FEMBAF Means 33
Introduction

Balance and postural control are critical elements for effective and efficient performance of everyday activities. A quick literature search reveals that balance in the elderly is an extensively researched topic because of its relationship to fall risk and fall prevention. Physical therapists play a large role in assessment of fall risk and prevention and so require easily administered, quantitative balance measurement tools and the most appropriate interventions to help an elderly person regain his/her balance skills and decrease risk for falls.

Three main sensory systems—vision, vestibular and proprioception—are required for maintaining balance. Age-related changes occur in each system, but one of the more pronounced changes occurs with vision. After the sixth decade, many people tend to have a rapid decrease in vision. For instance, a group of ophthalmologists found that people 75 years of age or older were 12.5 times more likely to have impaired vision and 78 times more likely to have severe visual impairment than people younger than 75 years old.¹ Yet, Maki and McElroy² hypothesized that with increasing age some individuals may rely more on vision than on vestibular and proprioceptive information for balance. A study conducted of 136 participants aged 59-97 years found that 43% of the participants who had experienced one or more falls in the past year were significantly more visually field dependent on two visual function tests than the other 57% of participants who had not fallen.³

The Beaver Dam Eye Study⁴ found that a consistent relationship exists between falls, hip fractures and visual function. The visual functions tested were best-corrected visual acuity, current binocular acuity, near acuity, contrast sensitivity and visual
threshold to light. The authors of the study found that subjects who were more than 60 years of age and classified as having poorer best-corrected acuity, decreased current binocular acuity, poorer near acuity and increased visual sensitivity to light were more likely to have had two or more falls. The same was true for subjects who had hip fractures—those with poorer vision on all of the measures were more likely to have had hip fractures. Furthermore, the results revealed those subjects with greater disparity between the eyes (i.e. difference in visual function between the right and left eye) for all visual functions tested had slower gait speeds. Gait impairments, such as slower gait speed, have been associated with increased risk of falling. Other studies have also demonstrated that alterations in the visual, vestibular and proprioceptive systems associated with aging have been correlated with a decrease in balance and, thus, an increased risk for falls.

The percentage of people over age 65 relative to the total population is steadily increasing in the United States. With this rise in the elderly population will also come an increase in the number of falls and injuries related to falls, unless preventive measures are taken to address this issue. Contemporary researchers in a variety of disciplines are working towards understanding the relationship among postural control mechanisms, age-related physiologic changes, environmental conditions (such as shoe sole thickness, lighting, and support surfaces) and intrinsic/extrinsic conditions that contribute to the incidence of falls. Researchers have also focused on determining whether falls occur as a result of 1) displacement of the center of mass (COM) beyond the base of support (BOS); 2) a perturbation to the BOS preventing realignment of the BOS underneath a moving
COM; or 3) because of no obvious mechanical perturbation, but rather a transient physiological event or a sensory perturbation occurred.\textsuperscript{12}

Tinetti et al.\textsuperscript{5} found that a multiple-risk-factor intervention program caused a significant reduction in the risk of falling among elderly persons living in the community. Risk factors assessed and addressed included postural hypotension, use of any benzodiazepine or other sedative-hypnotic agent, use of four or more prescription medications, inability to transfer safely to the bathtub or toilet, environmental hazards for falls or tripping, gait impairments, any impairment in transfer skills or balance; and impairments in leg or arm muscle strength or ROM (hip, ankle, knee, shoulder, hand, elbow). Numerous studies have evaluated the effectiveness of a variety of exercise programs, such as tai chi,\textsuperscript{13,14} individualized exercise programs,\textsuperscript{15} progressive resistance training and walking,\textsuperscript{16,17} training on a balance board with altered sensory inputs,\textsuperscript{18} training using visual feedback,\textsuperscript{19} a set of activities performed with eyes open and eyes closed,\textsuperscript{20} and a program involving dance steps, music and functional activities (such as sit-to-stand),\textsuperscript{21} as a means to increase one’s balance and mobility, and thereby decrease the risk of falling. Outcomes of the studies vary.

Despite the fact that much research has been conducted on improving balance in the elderly through exercise programs to reduce the risk of falls, none of the studies, to the authors’ knowledge, have specifically focused on determining whether or not balance training with one’s eyes open (EO) or eyes closed (EC) has a greater effect on balance test scores. Since vision and vestibular function decline with age, emphasis must be placed on the somatosensory system for improving one’s balance. Some of the studies that have used force plate measurements of postural sway as their outcome measure have calculated
postural sway with the subjects’ eyes open and with their eyes closed, however, the exercises in the training program have been performed both ways as well.\textsuperscript{20}

Since physical therapists are being challenged to elicit the most improvement in a client’s function in the fewest number of visits possible, determining the most effective way to assist a person whose balance deficits are predominantly related to intrinsic factors (musculoskeletal dysfunction, sensory changes, anticipatory and adaptive mechanisms, etc.) is important. With rising healthcare costs and an increasing emphasis on preventive care, the significance of training balance in an effective and efficient manner is clear.

The purpose of this study was to determine if: (1) balance test scores of elderly subjects will improve after a series of nine training sessions; and (2) a significant difference exists between the balance test scores of elderly subjects who practice balance activities with their eyes closed and those who train with their eyes open. It was hypothesized that the subjects would improve in their Fast Evaluation of Mobility Balance and Fear (FEMBAF) scores and the EC training group would show greater improvement scores than the EO group. Given the cost and time constraints placed on most clinicians, the FEMBAF was selected because of its ease to administer, variety of dynamic balance tasks included in the test and its ability to provide valid and reliable measurements of fall risk factors, functional performance and mobility limiting factors.\textsuperscript{22}
Review of the Literature

Because of the multitude of factors related to balance, a review of literature about balance must also cover a wide array of topics. This review of the literature consists of five main sections. The first portion examines the incidence and complications of falls in the elderly. The second section details the risk factors for falls. In the third section we discuss the age-related changes that occur in the three main sensory systems and how the changes relate to balance. The fourth section of the review covers the variety of balance tests designed to objectively measure balance, mobility, and postural sway, and the interaction of these three factors. Finally, the last section of the literature review includes a discussion of how the type, number and length of training sessions, and activities used for training affect the outcome measures for balance, mobility and postural sway.

Incidence and Complications of Falls

Falls constitute a serious threat to the health of the older adult population, because injury and/or death may result from a fall.\textsuperscript{23} The risk of falling grows exponentially as people age and it is estimated that approximately 25-35 percent of people over the age of 65 will fall each year.\textsuperscript{6,24} Falls are now the leading cause of morbidity and accidental death in elders.\textsuperscript{8} Since the number of people over the age of 65 is growing in the United States, the number of fallers may likewise be expected to increase.

Less serious than death, but still of major concern is loss of independence as a consequence of falling. Tinetti and Williams\textsuperscript{25} found that at least two noninjurious falls or at least one injurious fall were each associated with a decline in basic activities of daily living (BADL) and instrumental activities of daily living (IADL) function over three years. Approximately 50 percent of people who fall report requiring an assistive device
afterwards and 25-50 percent are discharged to nursing homes following their fall regardless of their level of assistance prior to the accident. As many as 25 percent of patients report that they consciously avoid previously performed activities for fear of falling again.17

Risk Factors for Falls

Numerous studies have tried to assess the most likely risk factors for falls.6-8,27 Deterioration of balance and postural control is often considered to be a primary risk factor for falls. In a study of 131 people Kanten et al.8 found that the population with the highest likelihood of falling was elderly women with severe balance disorders as well as some cognitive impairments. Other researchers have shown that having impaired balance combined with being mobile increased the probability of falling.26 Topper et al.12 looked at the percentage of falls of 100 elderly adults that occurred when mobile, when standing and receiving a push, and when standing with no obvious mechanical perturbation. Fifty-four percent of the falls observed occurred while the subjects were mobile (the person's base of support was prevented from being aligned beneath the center of mass, i.e. a slip or trip), while only thirty-two percent occurred as a result of a push or collision (the center of mass becomes displaced beyond the base of support). The remaining 14% of falls occurred due to some transient physiological event such as postural hypotension, cardiac arrhythmias or an alteration in sensory information.

Studenski et al.7 found recurrent falls were 4.8 times more likely in elderly people who were both mobile and unstable, with a much lower risk for people who were immobile or mobile and stable. In this same study the researchers also examined a four-domain predictive model of falls. They found that limited mobility alone is not the only
element in the risk of recurrent falls; rather, attitude toward risk, and environmental factors together with limited mobility were the most predictive of risk.

Risk factors associated with falling can be described as intrinsic or extrinsic. Intrinsic factors are those internal to the individual, such as changes in muscular strength, decreased joint flexibility, impaired visual sensation and a decline in vestibular function. Extrinsic factors are those associated with the environment, for instance, the presence of a rug or a slippery surface, and the intensity of lighting. Shumway-Cook, Baldwin, Polissar, and Gruber found that most falls in the elderly occur because of an interaction of both intrinsic and extrinsic risk factors. They found the risk factors most associated with falling are balance deficits, use of assistive devices, gait impairments, and a history of imbalance. Also, they discovered was much more variability in scores for these risk factors between the 'fallers' than there was between the 'nonfallers'.

Another risk factor contributing to falls is the speed necessary to recover stability when one loses his or her balance. Many older adults lack the speed necessary to recover stability. Woollacott, Shumway-Cook, and Nashner examined postural control in 12 adults aged 61-78 years compared to 14 younger subjects aged 19-38. The focus was on coordination of timing of muscle response to postural perturbation and the ability to reorganize sensory inputs for modifying postural responses. Testing was done on a moveable platform, which translated anterior-posterior to produce sway of the subjects COG. In some situations visual enclosure was used to provide incorrect visual information. Woollacott et al. concluded that the latency of distal muscle responses within a postural response synergy increases in older adults. Also, the ability of the older
adults to balance was impaired when they were confronted with incorrect visual and/or somatosensory inputs as compared to the younger subjects.

In addition to decreased muscle coordination and timing, decreased muscle strength in the elderly contributes to poor balance and an increased fall risk. Hurley, Reese, and Newham\textsuperscript{29} tested the strength of the quadriceps muscle in 20 young, 10 middle aged and 15 elderly subjects. With increasing age, a significant decline in quadriceps strength was found. The authors claimed that this decrease in strength was found to place a greater reliance on muscle proprioceptors and was hypothesized to contribute to increased fear and frequency of falls.

When assessing fall risk in the elderly the aging theory must be considered.\textsuperscript{30} This theory has three components related to falling---functional reserve, variability and how impairments affect function. Functional reserve is the idea that an amount of reserve in all of our physiological functions allows one to have some decline before any clinical symptoms appear. In the older faller, the systems for balance may be impaired gradually over time, yet balance problems may not be evident until the functional reserve is exhausted.

The second component of the aging theory is that with increasing age there is much larger variability between individuals both physiologically and functionally.\textsuperscript{30,31} Therefore, it is difficult to examine precisely what deficits are directly or indirectly related to falling. Lastly, the aging theory presents the notion that the sum of an individuals physiological impairments may not be representative of that person’s function. In other words, slight physiological impairments may present as severe
functional deficits in one individual, whereas similar impairments may only be of slight functional concern to another person.

**Age-Related Sensory Changes**

The ability to maintain postural stability and balance is achieved through three intrinsic systems--vision, vestibular function, and proprioception. As age increases, the mechanisms of balance change and the ability to recover stability following a trip or slip on a surface may not occur fast enough to prevent a fall. Although the mechanisms underlying falls have not been solely associated with any one of these physiological age-related changes, it is believed that these changes do increase the risk of falling.

Age-related physiologic changes in the eye may affect a person’s balance. Vision is an important source of sensory input that specifies spatial orientation. With age, the pupils of the eye become smaller resulting in decreased accommodation with differences in lighting, and a subsequent increase in the time required to adjust to lighting changes. Another visual change is a decrease in flexibility of the lens, which contributes to presbyopia--the inability to accommodate near vision while far vision remains normal.  

These usual changes in vision impede function by making it difficult to detect obstacles and different ground surfaces, which increases the risk of losing one’s balance and falling. Additionally, it is hypothesized that older individuals tend to rely on vision more than vestibular or proprioceptive systems than do younger people. This combined aspect of decreased functions with an increased dependence on the visual system makes increased fall risk with ageing even more significant.

Vestibular function, similar to visual function, undergoes physiological changes with age. The vestibular apparatus consists of three semicircular canals arranged three
dimensionally in planes that lie at right angles to each other. Each canal is filled with fluid and contains thousands of receptive hair cells. With acceleration or deceleration of the head, the fluid lags behind causing bending of the hair cells. In turn, neurons relay the message from the hair cells to the cerebral cortex that the head is moving. In addition to the semicircular canals, the vestibular system consists of sac-like structures—the utricle and saccule. Similar to the semicircular canals, these structures also contain hair cells and fluid. Otoliths, or stone-like structures, lie within the fluid on a gelatinous membrane that indirectly links the otoliths to the hair cells. Movement of the head causes the otoliths to displace the hairs, in turn causing neurons to relay information to the cortex about the position of the head relative to gravity and linear motion.³³

Studies of the vestibular system show up to a 20 percent decline in the number of hair cells in the saccule and utricle and a 40 percent decline of hair cells in the semicircular canals with ageing.³⁴ These physiological changes have been noted to cause significant functional decline in the vestibular system. For example, when warm water was placed in a young person’s ear they tended to respond with large amplitude, involuntary movements of the eyes, while older subjects responded with a lesser magnitude of eye movement.³⁵ This decline in vestibular function may lead to an older person having difficulty with detection of linear and angular movement of his/her body.

Morphological changes also occur in the somatosensory system as we age. For instance, specific receptor cells for the touch sensations begin to decline in number. In addition, an age-related decline in the number of afferent nerve fibers occurs. This decrease of somatosensory input has been found to correlate with increased instability and a higher number of falls in the elderly.³⁶ The proprioceptive component of the
somatosensory system does not appear to decline with age. Benassi and colleagues found that proprioception was rarely affected in neurological screening of patients aged 67-87 years. Similarly, perceptions of passive movements in metacarpophalangeal and metatarsophalangeal joints were found to be similar in both young and older subjects.

**Balance Testing**

Along with the variety of changes that occur with ageing comes a variety of assessment tools to measure the impact that intrinsic and extrinsic factors have on one’s balance. Balance assessment tools may be broadly divided into two main categories of static and dynamic balance tests. Static balance indicates conditions where the base of support (BOS) and body remains relatively stationary, as when standing, lying or sitting. Dynamic balance indicates conditions where the body and/or its segments are in a state of motion, such as when walking, running, jumping, throwing, or lifting. Some studies combine static and dynamic measures to allow comparison between the measures.

**Static Balance Testing**

Commonly used static measures of balance include single limb support, Romberg test, and the Sharpened Romberg. The Romberg test requires a person to stand with arms folded across his/her chest for as long as possible, up to one minute, with the eyes open and then with the eyes closed. To perform the Sharpened Romberg, a person maintains a tandem stance with eyes open and then eyes closed for as long as possible, up to one minute.

Three other tests of static balance, the Postural Stress Test (PST), developed by Wolfson et al., posturography, and the Clinical Test for Sensory Interaction in Balance (CTSIB) require more equipment than the previously mentioned measures, however
they can also provide objective, quantifiable data. The authors consider these to be static measures because the body and/or its segments do not move, rather perturbations are applied to the body in some fashion. The Postural Stress Test (PST) requires external perturbations be applied to a subject through a harness attached around the subject’s trunk. Subjects are scored based on the magnitude of their balance reactions (i.e. ankle, hip and stepping strategies). While the PST is a quantitative measure of one’s ability to maintain the body’s center of mass within its base of support, the equipment required to perform the test makes it less accessible in clinical practice.

Posturography involves using computer technology to aid in measuring a person’s postural sway under six different sensory conditions. The CTSIB, a similar, yet much less expensive version of posturography, assists a clinician in determining which of the three main sensory systems is contributing to a person’s balance deficit, and thus, may need to retraining to improve his/her balance. To successfully complete the test, a person must maintain his/her balance with the feet together and the hands on the hips for thirty seconds in six conditions: 1) standing on the ground with the eyes open (baseline measure); 2) standing on the ground with the eyes closed; 3) standing on the ground with the eyes open with a modified Japanese lantern over the head to alter the accuracy of visual input; 4) standing on a compliant foam surface with eyes open; 5) standing on foam with the eyes closed; and 6) standing on foam with the modified Japanese lantern over the head. Objective measures for the CTSIB are obtained by timing how long a person maintains his/her balance under each sensory condition. These tests are useful for a clinician if he/she wishes to analyze a person’s static balance, however, more falls occur during movement, which entails dynamic balance.
Researchers have attempted to determine if subject’s responses to internal perturbations are correlated to their response to external perturbations. To test this hypothesis, Fishman, Colby, Sachs, and Nichols\textsuperscript{13} compared twenty subjects’ responses to self-generated upper-extremity balance tasks (Functional Reach Test, arm raise and arm reach tasks) with responses to external perturbations on the Balance System\textsuperscript{TM} (postural sway, symmetry of weight distribution). They found no relationship between responses to balance tasks involving upper extremity movements and the force platform measures.

This study is important because a majority of the falls experienced by the elderly result from self-generated movement such as reaching, turning and transferring, not from an external perturbation like that generated by the Balance System\textsuperscript{TM}. Therefore, using posturography testing or force platform measures of postural sway may not be clinically relevant when trying to assess whether or not a patient has improved his/her balance and whether or not he/she is at a lower risk for falls.

Dynamic Balance Testing

Since self-generated movements relate to many of the falls incurred by the elderly, the Functional Reach Test (FRT) is a quick screen for balance problems in the older adult.\textsuperscript{15} Standing with the feet shoulder width apart and an arm raised to 90° flexion, the FRT requires the subject to reach as far forward as possible without a loss of balance. Age-related norms have been established and Weiner et al.\textsuperscript{44} determined that the FRT is sensitive to change by studying 28 inpatient male veterans in physical rehabilitation compared to 13 control subjects not involved in rehabilitation. Francignoni et al.\textsuperscript{45} determined that the FRT had good inter-rater and test-retest reliability when the test was administered to healthy women aged 55-71 years. A reach of less than six inches is
predictive of an increased incidence of falls in the elderly. A similar test, the Lateral Reach Test, developed by Brauer and Burns, requires a person to stand with the heels 10 cm apart, both arms abducted to $90^\circ$ for 10 seconds and then reach to each side as far as possible without stepping or lifting the feet. Like the FRT, the lateral reach test has high test-retest reliability, however, the test is not useful for persons with various upper extremity impairments and the tests do not require movement of one’s center of mass over a changing base of support.

In an attempt to provide more easily accessible objective balance measures, Cho and Kamen tested how accelerometry, a portable, postural sway measuring technique, compared to a modified Romberg, a modified FRT, a 10-meter walk test, a heel-toe transition and a rapid stepping test, to distinguish between healthy older people and idiopathic frequent fallers. Accelerometry, an alternative to force platform testing, measures the excursion of the head and hips under eyes open and eyes closed conditions on a solid floor and on a compliant foam surface. An interesting finding of this study was that the FRT did not reveal any significant differences between the group of healthy older people (n=8) and the group of idiopathic frequent fallers (n=8). Walking velocity on the 10-m walk test was faster for healthy older subjects than for the idiopathic fallers. Healthy older subjects performed the rapid stepping task more quickly than the idiopathic fallers. The accelerometry measures, especially measures from the sensor on the head, did differentiate between healthy older subjects and idiopathic frequent fallers by showing that fallers had a greater amplitude of sway. Even though accelerometry and posturography may provide objective, quantitative data, measures of postural sway do not necessarily provide any additional or better information than that which can be gained
from other tests such as the rapid stepping or 10-meter walk test, which do not require expensive equipment. Changes in postural sway may not necessarily correlate to improved functional ability and a decreased fall risk.

Another clinically accessible and simple-to-administer balance screening test that involves a response to internally generated movement, and correlates to fall risk, is the "Get-up and Go" test, developed by Mathias, Naysk and Isaacs, and the modified version, the "timed up and go" test. The "Get-up and Go" test is a qualitative analysis of how a person rises from a chair, walks three meters, turns around and returns to sitting in the chair. To quantify the test to provide objective data, the modified version measures the time it takes a person to perform the activity. Although simple to administer and relevant to balance, the authors have not chosen to employ this test because normal, healthy elderly subjects are not expected to show any abnormalities on the test.

The Gait Abnormality Rating Scale (GARS) is another assessment tool designed to determine the relationship of gait abnormalities to falls in the elderly. First developed by Wolfson et al. in 1990, the original GARS involved videotaping a person from an anterior and a lateral view while he/she walked for 10 meters on a level surface; and then analyzing the gait pattern based on 16 items. A subsequent version, the Modified GARS (GARS-M), only includes seven of the original sixteen gait analysis items that had the most reliability and validity to predict fallers versus non-fallers. Although the GARS-M has high intra-rater reliability (.968) and inter-rater reliability (.968), clinical experience factors into the inter-rater reliability measure, learning how to score the test is time-consuming, no normative values exist for determining the fall-risk category, and the GARS-M study only included community-dwelling male veterans over 60 years old.
To obtain a more comprehensive clinical picture of a person's balance, assessment tools that combine static and dynamic measures may be more useful.

**Combined Static and Dynamic Testing**

A number of authors attempt to combine dynamic measures of balance with static measures, to provide objective, quantitative data. Topper, Maki, and Holliday\(^1\) performed an activity-based balance and gait test and a posturography test on 100 volunteers (mean age = 83, SD = 6) and then monitored the subjects' types of falls in the ensuing year. They found that subjects whose performance was rated as "abnormal" on the activity-based test related to transfers, turning or reaching were more likely to experience one or more falls in similar daily activities. Therefore, an activity-based assessment can help identify areas and activities in which a person may need assistance in developing better strategies to minimize the risk of falling.

The Performance-based mobility assessment (identified as the B-POMA), developed by Tinetti et al.,\(^5\) to identify people at high risk for falls, includes a balance and a gait component. Designed for people over 65 years of age living in institutions and the community, the test requires a person to perform 16 different tasks which the rater scores on a 0-1 or 0-2 scale. Interrater and intrarater reliability and predictive validity have been established; however, the test may not be sensitive to change.\(^5\)\(^2\),\(^5\)\(^3\)

Similar in content to Tinetti's B-POMA is the Berg balance test,\(^5\)\(^4\) which also contains static and dynamic balance measures. Each of the 14-items in the Berg balance assessment are rated on a four-point scale, with the higher scores indicating better balance and lower scores indicating a greater fall risk. The items included in the Berg are sit to stand transfers, standing unsupported with eyes open and eyes closed, sitting unsupported
with feet on the floor, transferring from a bed to/from a chair, standing unsupported with the feet together, reaching forward, picking up an object from the floor, turning to look over the left and right shoulders, turning 360°, touching a foot stool with the left and right feet, tandem standing and single leg standing. Despite the fact that the Berg balance test includes a variety of static and dynamic situations, it does not include a systematic way to include information about risk factors that are not movement related.

In an attempt to integrate risk factor assessment, physical performance, and mobility, Arroyo et al.\textsuperscript{55} developed the Fast Evaluation of Mobility, Balance, and Fear (FEMBAF) as a screening tool. The FEMBAF, a simple and comprehensive method of evaluating the mobility and balance of the elderly, was validated in a group of 241 old healthy individuals (mean age of 77.5 years, standard deviation 7.9 years) living in the community. The individuals were independent with basic activities of daily living and instrumental activities of daily living, and more than 50% had a good level of physical activity; 59% had fallen at least one time in the year prior to the test and 45% of these fallers required nursing or medical attention. The authors found a significant difference between fallers and non-fallers on performance of the test. They also found that fear complaints were significant and specific to the group of fallers. Based on Arroyo et al.'s findings, they suggest that a score greater than 45 on the task completion portion is considered normal, 35-45 points indicates moderate fall risk, and a score of less than 35 points indicates a severe fall risk.

To determine the reliability and validity of the FEMBAF, DiFabio and Seay\textsuperscript{22} compared the Fast Evaluation of Mobility, Balance, and Fear (FEMBAF) to the Timed Up and Go, the Functional Reach, and the Tinetti Performance Oriented Mobility
Assessment (B-POMA). They found that the correlation between the task completion portion of the FEMBAF and the B-POMA was .91, to the CTSIB was .54, and to the Timed Up & Go Test was -.58 (each was significant at p<.05). In other words, subjects who scored higher on the task completion portion also had higher scores on the B-POMA and had longer stance durations on the CTSIB. Subjects whose scores were lower on the task completion portion were associated with increased Timed Up and Go duration.

Significant correlations (p<.05) were also found between the risk factor portion and the other three comparison tests. The correlation between the risk factor part of the FEMBAF and the B-POMA was -.69, to the CTSIB was -.46, and to the Timed Up and Go was .37. Lower stance durations on the CTSIB were associated with a great number of risk factors. Interrater reliability on determination of risk factors had a mean of .95 (SD=.15) and on task completion the mean was .96 (SD=.12). The FEMBAF identified more subjects (31/35) at risk for falling than did the B-POMA (15/35) and the CTSIB (22/35).

The authors of the present study have chosen to use the FEMBAF as a measurement tool because it combines subjective and objective measures of a person’s fall risk, it has been shown to have good validity and interrater reliability on a similar population, and it only takes about fifteen minutes to administer. The questionnaire portion of the test includes questions pertinent to assessing fall risk, as has been demonstrated by other studies (See Appendix A). The second part of the FEMBAF involves performance of a variety of common functional tasks, such as standing up from a chair, stepping over an object and walking; and more challenging activities to balance, such as jumping, climbing stairs and standing from a kneeling position (see Appendix B). The more challenging activities can help counter a ceiling effect, which may occur in a
healthy, elderly population. A decreased ability to perform the tasks is associated with an increased fall risk, as has been demonstrated through previously cited studies.

**Balance training programs**

Various factors, such as length of training, number of training sessions per week, exercises used for training and assessment tools used for outcome measures make studies about balance training challenging to compare. A constant variable in the following studies is that the subjects are healthy, elderly (mean 62 years old) adults.

Some balance training studies employ a general training approach, meaning that participants do not receive individualized therapeutic exercise programs, rather all subjects participate in the same activities. Judge, Lindsey, Underwood, and Winsemsius\textsuperscript{16} used this general approach by studying a group of healthy, community-dwelling elderly women who either participated in a combined training group or a flexibility and postural control group; test subjects trained for three times per week for six months and the control group performed their program once a week. The combined training group used knee extension and sitting leg press machines, performed twenty minutes of walking, and did postural control and flexibility exercises (which included simple tai chi movements). Using a force platform measure of balance, the researchers found a significant decrease in the amount of sway in single limb stance in the combined training group, but no change in the flexibility training group. The 17\% improvement in mean displacement of the center of pressure in single limb stance on the force platform found in the combined training group was not significantly different from the flexibility training group. Unfortunately, it is unknown if a decrease in sway in single limb stance translates into improved function and a decrease in fall risk. One would like to assume that a decrease in
postural sway indicates that a person has better balance, but single limb stance is only a
dynamic measure of balance.

Johansson and Jarnlo \(^{21}\) discovered significant improvement in six of nine
functional skills tests among 34 community-dwelling 70 year-old female subjects who
received one hour of training twice per week for five weeks. Training activities consisted
of dancing steps, sit-to-stand, weight transfer exercises in sitting and standing, walking
changing speed and direction, and mobility and strength exercises all accompanied by
music. \(^{21}\)

A second study also employing a five-week training period, \(^{20}\) like Johansson and
Jarnlo’s study, compared the effects of a short-term balance training program on the
postural stability of elderly adults with a history of falls to those without a history of
falling and to a control group. The program consisted of three, one-hour sessions per
week for five weeks. During the sessions participants performed activities which included
one leg standing, neck hyperextension, free leg swinging, heel and toe raises, point
fixation, reaching up high to move objects, walking in place, and sideways, grapevine,
backward, and response walking. Seidler and Martine \(^{20}\) found that this short-term
intervention produced significant improvements of 5-10% by the fallers and nonfallers
groups on a modified version of the Tinetti Performance-oriented Assessment of Balance
as compared to the control group, but there were no significant differences between the
two training groups in their pretest and initial posttest scores. Also of interest and
relevance to the present study, was the finding that laboratory measures (postural sway
measures) provided little support for the effectiveness of balance training.
Yet another study, using a general training approach, by Verfaillie, Nichols, Turkel and Hovell\textsuperscript{17} involved random division of their relatively healthy, community-dwelling elderly subjects (aged 65 to 83 years) into two groups—a strength and balance/gait training group and a control group who received strength and relaxation training. Following twelve weeks of training, both groups demonstrated a significant increase in their strength and gait speed. This translates into a decreased fall risk because decreased gait speed increases one’s fall risk. Since these studies demonstrated gains with general programs, the authors of the present study have chosen to use a general approach in an attempt to isolate the variable of vision. These results also support the benefit of exercise groups.

Nordt, Sachatello, Plotkin and Dintino\textsuperscript{56} conducted a 30-day balance program for 25 subjects living in assisted living facilities who were identified as experiencing balance difficulties. Subjects met for about one hour three times per week to perform balance board activities. The researchers found that 97% of the participants enjoyed the program, 95% of the subjects had a subjective improvement in confidence level and a diminished sense of balance loss and 90% of the subjects demonstrated an objective improvement in balance.\textsuperscript{56} Objective measures consisted of the static balance tests of right single leg stance, left single leg stance, and Sharpened Romberg with eyes open and eyes closed. A stopwatch was used to time how long the participant maintained each testing position.

The Atlanta FICSIT (Frailty and Injuries: Cooperative Studies of Intervention Techniques)\textsuperscript{13} study examined the effects of tai chi quan and computerized balance training on postural sway in relatively inactive elderly subjects after fifteen weeks of training. Subjects in the computerized balance training group demonstrated greater
stability on post-test platform balance measures as compared to the tai chi training group, perhaps due to a learning effect since testing and training procedures were similar. However, the tai chi group reported a greater increase in confidence in their balance, and having greater confidence in one’s balance encourages mobility. It is believed that elderly adults decrease their activity level because of a lack of confidence in their balance and that this decreased activity may contribute toward a downward spiral of even less mobility and decreased function.

In contrast to the general training approach, Shumway-Cook, Gruber, Baldwin, and Liao conducted a study on the effect of individualized exercise programs (multidimensional exercises) on the balance, mobility, and fall risk of elderly adults. Subjects were divided into a fully adherent exercise group, a partially adherent exercise group and a control group of fallers. The fully adherent exercise group attended outpatient physical therapy sessions two times per week for 8 to 12 weeks and exercised 5 to 7 days per week at home. The partially adherent exercise group attended less than 75% of their required therapy sessions and exercised fewer than 4 days per week. The control group received no intervention. After evaluation by a physical therapist, subjects received individual exercise programs that targeted identified impairments and functional disabilities. Following eight to twelve weeks of the intervention, subjects in both exercise groups demonstrated significantly improved scores on all balance and mobility measures and the fully adherent exercise group had the greatest reduction in fall risk.

Hu and Woollacott found that after a ten-hour multi-sensory balance training program over the course of fifteen days, elderly subjects showed significantly improved stability on platform measures. The testing and training measures were conducted on a
platform system, which is not readily accessible in most clinical practices, and subjects could have shown a learning effect because of being tested and trained on the same apparatus. The present study attempts to use equipment readily available in most physical therapy clinics or a subject's home and uses a pretest/posttest measure that requires minimal time and equipment to administer. Further, this study attempts to isolate one sensory variable—vision.

Maurer et al.\textsuperscript{18} found that a twenty-minute balance training protocol, three times per week for three weeks increased standing balance and Functional Reach test measurements in a sample of nine healthy active subjects, aged 62 to 73 (no control group). Subjects were required to maintain their balance with their eyes closed and head tilted, while standing on a custom designed balance board. The authors used the CTSIB (performed in single limb stance) and the FRT as their pre- and post-test measures. Given the current third-party payer system and the limitations placed on physical therapy visits per patient, a protocol of three times per week for three weeks design is more clinically applicable and feasible than a twelve-week long program. Since this study demonstrated gains in three weeks, we have chosen to follow a similar short-term training approach.

Other factors contributing to balance

Besides determining how to measure balance, other contributing factors such as footwear, self-perception, fear and knowledge of fall risk factors play a role in balance analysis. Robbins, Gouw, and McClaran\textsuperscript{10} conducted a study on how shoe sole thickness and hardness influence balance in healthy men aged 60 years or more. They found that shoes with thin, hard soles provided optimal stability, while shoes with thick, soft midsoles, such as running shoes, were deemed the most comfortable, but also caused
greater balance failure. Being barefoot caused an even higher frequency of balance failure.

Along the same lines, Arnadottir and Mercer\textsuperscript{57} conducted a study to determine the effect of shoes on the outcome of three common balance tests—the Functional Reach Test (FRT), Timed Up and Go (TUG) and the 10-meter walk test (TMW). They discovered that FRT scores improved in walking shoes or barefoot compared to dress shoes. Subjects FRT scores were, on average, 15\% lower when wearing dress shoes; and no significant difference existed on FRT scores between barefoot and walking shoe conditions. Subjects achieved the best TUG and TMW scores in walking shoes and the worst scores in dress shoes, and intermediate scores when barefoot. Thus, they concluded that footwear affects FRT, TUG and TMW measurements in older women. With this knowledge, subjects in the present study were asked to wear their typical walking shoes so that they would train in the shoes they most frequently wore.

Another factor less commonly discussed in regards to balance is the psychological factor. Tinetti, Mendes de Leo, Doucette, and Baker\textsuperscript{58} assessed how the fear of falling and fall-related efficacy relates to community-living elders’ activities of daily living-instrumental activities of daily living (ADL-IADL), and physical and social functioning. Fall-related efficacy indicates the degree of confidence a person has in performing his/her daily activities without falling. Subjects with a history of falling had lower scores on the Falls Efficacy Scale than nonfallers, which means fallers were less confident in their ability to perform ADLs and IADLs without falling. Therefore, a person’s perceptions about his/her balance must be considered in an intervention program.
The importance of self-perception is demonstrated in another recent study. In a four-months post-intervention follow-up assessment of the participants at the Atlanta FICSIT (Frailty and Injuries: Cooperative Studies of Intervention Techniques) site, Kutner et al.\(^{14}\) reported that the subjects who received tai chi training and the subjects who received individualized balance training felt increased confidence in their balance and movement. Additionally, tai chi subjects were significantly more likely than the balance training group and the control group to report "a noticeable effect on their life, effects on activities of daily life, change in normal physical activity, and a sense of having benefited from their exercise training".\(^{14}\)

Continuing in a like manner, Lachman et al.\(^{59}\) developed the Survey of Activities and Fear of Falling in the Elderly (SAFE) as a means to evaluate an older person's fear of falling and the extent to which that fear limits the person's activities and quality of life. Along with completing the SAFE, participants in the study also completed four measures of quality of life (MOS Short Form 36, Social Support and Leisure time activities measure from the Normative Aging Study, and an overall life rating) and two additional measures of fear of falling (Falls Efficacy Scale [FES], and three other items). Results of the study revealed that individuals with higher fear scores participated in fewer activities and were more likely to have reduced their activities during the past five years. Also, women and older individuals, those who had experienced a previous fall, and those who used an assistive device for ambulation or had more medical conditions were more afraid of falling. Fear of falling and quality of life measures were correlated in that more fear was associated with poorer quality of life and those who were more afraid of falling had poorer physical functioning and mental health and had fewer social contacts.
Braun\textsuperscript{60} also investigated older individuals' knowledge and perception of fall-related risk factors by conducting a survey of people aged 62-99 years (mean 78.8 years) living in government-subsidized apartments. Respondents of the survey considered falling a major preventable health problem for elderly people, but listed falling only as moderately important compared to other health concerns. Interestingly, when answering questions about themselves, respondents expected themselves to be at a lesser risk of falls due to the risk factors than the general elderly population. Participants who considered falls a concern ranked personal/physical and exterior environmental risk factors higher than those who responded that falls are not an important concern. Those who rated their health as poor-fair and those who said a fear of falling limits their activities placed greater importance on physical fall-risk factors. Most respondents considered themselves to be at a risk of serious injury after a fall, but thought they could return to their previous living situation. Overall, respondents considered exterior environmental factors the most important fall-risk factor and then physical factors, while psychological factors were considered the least important.

In summary, balance and balance training involves multiple systems and components that overlap and weave together to create postural stability. As is clear by the vast array of literature cited here, it has been of great importance to many researchers to determine which components of balance are most predictive of falls, how to most efficiently improve a person's balance ability and how to decrease the risk of falls in the elderly.
Method

Experimental Design

A two-group, pretest-posttest randomized-groups design was used to determine whether training normal, elderly subjects with eyes open (EO) or eyes closed (EC) exercises would improve their balance test scores as compared to control subjects.

Subjects

Eighteen subjects (6 male, 12 female) were recruited for this study. Subjects were normal, elderly males and females (65 years of age and older) recruited through brief presentations at independent/assisted living centers, senior citizen centers, and through advertisements in the Washington county area of Oregon. Subject selection criteria included: the ability to ambulate without an assistive device; absence of severe neurological dysfunction; absence of severe musculoskeletal impairments; the ability to answer questions and follow three-step instructions appropriately (intact cognition); a history of fewer than two falls requiring medical attention in the past six months; and an absence of history of dizziness that impedes ADLs. People who used canes for ambulation were allowed to participate if they were able to ambulate and fully perform the tests and activities without the cane. Excluded were subjects with any medical or musculoskeletal condition (such as severe hemiparesis due to CVA, TBI, or other neurological insults) that would prevent full participation in the testing and training. Prior to testing, each participant signed an informed consent form in accordance with policies established by the Institutional Review Board at Pacific University. Subjects were randomly assigned to the eyes open or eyes closed group prior to administration of the pretest. There were no significant differences found in age, height, weight, or fall risk
between EO and EC groups. Subjects were instructed not to change their current activities or start any new exercise programs during the training time. Two of the original participants (1 male, 1 female) from the EO group, were unable to complete the study due to health complications unrelated to this study. One female subject from the EO group chose to discontinue the study prior to beginning the training sessions for fear of falling during the balance activities.

**Procedures**

To determine baseline data for each subject, the Fast Evaluation of Mobility, Balance, and Fear (FEMBAF) was administered. The FEMBAF involves taking measures of subjects' height, weight, gender, age, and living situation. It also includes a risk factor assessment questionnaire and a task completion portion. The risk factor questionnaire is a yes-no questionnaire, administered by the researcher, which addresses the subject's perception of his/her ability to perform activities of daily living, number of recent falls, fear of falling, use of medications and presence of somatic pathologies. The task completion portion includes one-footed standing, picking up a pen from the floor, stepping over an object, climbing stairs, rising from a chair, rising to standing from tall kneeling, and the Romberg test. Baseline data were taken on a day prior to the first training session.

Nine training sessions involved a circuit of five balance activities, a rest period and then repetition of the circuit. All of the five activities were self-paced and each was performed for one minute with a thirty-second rest between each activity. Five subjects, each starting at a separate station, performed the circuit as a group. Those in the EO group performed all activities with their eyes opened and those in the EC group performed all
activities with their eyes closed. Those in the EC group were asked to keep their eyes closed and wore sunglasses with black cloth taped over the front. Subjects were instructed to wear their regular shoes during the testing and training sessions. The activities were selected based on equipment that is commonly available in clinics, exercises used in other balance studies, and the clinical experience of the authors, and simplicity. The five balance activities included:

1. Walking over a ten-foot long mat with three sandbag weights spaced approximately two feet apart underneath the mat to create an uneven surface;

2. Turning in a circle to the right and to the left while standing on a pillow or foam cushion;

3. Shoulder extension performed with a piece of Thera-Band tied to a door handle. Repetitions were performed with both the right and left upper extremities while standing on a pillow or foam cushion;

4. Sit to stand repetitions from a chair with arm rests, and

5. Side stepping while standing facing a counter top.

Activities one, two and three were performed with stand-by supervision of a researcher. After completing a given activity, subjects rested for thirty seconds then rotated to the next activity until each participant had performed all five stations. Subjects were allowed to choose their starting points. Following completion of the first training circuit, subjects received a five-minute rest and then performed the circuit again.

The first three activities were chosen to mimic functional activities. Walking over an uneven mat was used because it mimics walking over uneven terrain. Common causes of falls are slips, trips, and missteps. Walking over uneven terrain is hypothesized to
increase the use of proprioception for foot placement. Turning in a circle while standing on a compliant surface encourages the use of proprioception and turning is a functional activity. Standing on a compliant surface and pulling on Thera-Band mimics a variety of typical ADLs that require one to reach out of one's BOS with an upper extremity. The authors modified the reaching exercise at the start of the second week of the training sessions to make the exercise more challenging. Initially subjects were asked to stand on a pillow and pull a piece of Thera-Band attached to a doorknob. However, the authors discovered that the subjects were not reaching beyond their BOS and limits of stability, therefore subjects were then asked to reach towards the wall with an upper extremity. The subjects were positioned so that they could not quite reach the wall and were asked to reach as far as they could without falling. This improved the movement out of one's limit of stability. Finally, subjects were asked to just reach forward as far as possible without touching the wall. These changes made the activity more challenging to the subject's balance.

Repeated movement of sit-to-stand is a functional strengthening activity for the hip and knee extensors, which are common muscle weaknesses among the elderly. Sidestepping at a counter was selected because hip abductor muscle weakness is also common among the elderly and it can be performed independently. After the fourth training session subjects were asked to perform crossover stepping instead of just sidestepping. The crossover step increased the challenge to subjects' balance. The subjects were allowed to touch the counter top for support.

In the middle of the second week of training, the order of the stations was reversed in an attempt to keep the stations from becoming monotonous. Background
music was also added to the sessions at this time as an auditory distraction to make the training more challenging. During the third week, the testers spoke with subjects during the three supervised activities to further increase the challenge of the activity.

Subjects met three times per week for three consecutive weeks, which resembled a typical clinical situation. Posttest measures were identical to the initial tests and were taken the week following the last training session. Prior to completing the posttest, one author asked the subjects to give subjective reports about how they felt about their balance after three weeks of training. The subjects’ initial and final FEMBAF scores were compared to determine if significant improvement in balance occurred in either of the two groups.

Data Analysis

Statistics were calculated from the data gathered from the pre- and post-test FEMBAF scores. A one-factor analysis of variance (ANOVA) was used to determine if any significant difference in pre-/post-test scores between the eyes open and eyes closed groups existed. Data was analyzed with Microsoft Excel and statistical significance was set at p< 0.05. One-way ANOVA’s were also used to determine if any significant differences existed between the height, weight, age, and number of fall risks for subjects in each of the groups.
Results

Improvement in FEMBAF scores of each subject was assessed by comparing pre- and post-test FEMBAF scores. Each subject's pre-test score was subtracted from his/her post-test score to calculate his/her FEMBAF difference score. No significant difference was found between the eyes open group and the eyes closed group in their FEMBAF difference scores. Mean pre-test and post-test scores for both groups are presented in the Figure.

Although no significant difference was found between the two groups in their balance scores, the two groups as a whole did differ significantly on pre- and post-test scores (pre-test scores mean = 42.8 ± 4.83 and post-test scores mean = 47.06 ± 3.78) with a p = .009. Mean and standard deviation values for height, weight, age, male:female ratio, and number of fall risks for both groups are shown in the Table.
Figure. Pre- and Post-Test FEMBAF Means

Table. Subject Demographics (n=16)

<table>
<thead>
<tr>
<th></th>
<th>Eyes Open Group</th>
<th>Eyes Closed Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td></td>
<td>(n=6)</td>
<td>(n=10)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>83.8 ± 9.47</td>
<td>84.4 ± 6.77</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>160.3 ± 4.80</td>
<td>164.5 ± 8.75</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>74.20 ± 11.18</td>
<td>83.68 ± 15.08</td>
</tr>
<tr>
<td>Male:Female</td>
<td>1:5</td>
<td>2:3</td>
</tr>
<tr>
<td>Fall Risk Factors</td>
<td>7.5 ± 2.8</td>
<td>6.7 ± 4.0</td>
</tr>
<tr>
<td>(from FEMBAF part 1*)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* See Appendix A
Discussion

The results of this study show that nine balance training sessions had an effect on the mobility and balance of elderly subjects living in two retirement communities. However, the results do not reveal a difference between training with eyes closed and training with eyes open. These results are consistent with other balance training studies in which subjects performed therapeutic exercises and improvements in balance and mobility were seen.\textsuperscript{13,15-18,20,21,23}

The primary weaknesses of our study may be described in three broad categories: 1) subject selection; 2) the measurement tool; and 3) variations in training techniques. The first area of weakness is subject selection. Our subjects were relatively active elderly and they were interested in doing something to improve their balance. Also, most of our subjects resided in retirement centers (one subject was a community-dwelling senior and two subjects lived in subsidized senior apartments), instead of community dwelling elderly. Given these considerations, there may be inherent differences between our subjects and people who did not participate, thus, there is a decreased ability to generalize the results to all elderly.

Our measurement tool, the FEMBAF, presents potential areas of weakness. The FEMBAF does seem to be a good tool for screening the elderly population to determine fall risk, however, as a research tool for pre-testing and post-testing subjects multiple variables exist which could lead to incorrect data. The vague descriptions of how to administer and score the FEMBAF is the primary concern with the use of this test.

Scoring of the FEMBAF is particularly vague when the subject receives a score of two on a task indicating that the task was initiated but the subject was unsteady or only
partially completed the task. The score of two is vague because there is no distinction between a subject who requires minimal assistance and a subject who requires maximum assistance to complete a task. This problem could be addressed by changing the rating scale to either: 1) a plus (+) and minus (−) system to distinguish between subjects who require minimal, moderate or maximum assistance to perform a test, or 2) include additional numbers such that a two represents completing the task with moderate-maximum assistance, three represents completing the task with minimal assistance and then a four represents completion of the task without any assistance.

Items 12 and 13 (see Appendix B) of the task completion portion require the tester to give the subject a nudge between the scapulae and then on the sternum. Although the same tester administered the nudge to all subjects for both the pre- and post-tests, it is unlikely that the magnitude of the nudge was identical for each subject. Items 12 and 13 are also difficult to score because the test does not specify which type of balance recovery strategy (ankle, hip or stepping) is acceptable or if one strategy should receive a two and another a one. Items 14 and 15 (see Appendix B) of the task completion portion, ascent and descent of five steps, are difficult to score because the test fails to specify how to score a subject if he/she employs a step-to pattern instead of a step-over-step pattern. The authors visually noticed differences in functional mobility between subjects who ascended and descended the stairs with a step-to pattern versus a step-over-step pattern, but these differences are not reflected in the subjects’ scores on the FEMBAF. For items 17 and 18 of the task completion portion, which require the subject to lean anteriorly and posteriorly to his/her limit, some subjects used a hip strategy and others used an ankle strategy. Unfortunately, the FEMBAF does not list which strategy is acceptable, nor does
it describe how to score a subject based on the strategy he/she uses. Another potential for error was found with items 17 and 18. After three weeks of training the subjects knew the authors better and may have been less hesitant to perform this skill than in the pre-testing session. Therefore, we believe these items may measure trust in the tester rather than an actual ability to perform the skill.

Another potential drawback of the FEMBAF is the inability to account for a subject’s mental status. For instance, one subject had some degree of memory loss because she did not remember what to do at each station, yet she remembered to attend each training session. The questionnaire portion relies largely on a subject’s ability to report his/her conditions and a decreased mental status may impede the accuracy of reporting; however, someone who knows the subject well could provide the answers to the questions.

When completing the questionnaire some ambiguity exists in question 21 regarding specific pathologies likely to induce falls (see Appendix A). The example of cataracts for sensory pathologies caused some confusion because if a subject has had the cataracts removed, should the question be answered yes or no? Another somewhat ambiguous question is walking device use, because some subjects only used a cane on an infrequent basis, which is not represented in the questionnaire.

The third main category of weakness is variation in training technique. Even though subjects wore blinders in the EC group, some subjects did open their eyes and used their vision during the activities. Although the blinders did block most of the subjects’ forward vision, some peripheral and downward vision was possible. When the testers noticed a subject’s eyes open, he/she was reminded to keep his/her eyes closed.
Subjects were also given the freedom to discontinue an activity if they experienced too much discomfort, such as dizziness or high blood pressure. For instance, one subject chose not to perform the sit-stand activity because she reported that her blood pressure escalated with the repetitions. One subject in the EC group did not close her eyes or wear blinders when walking across the mat. One subject performed mini-squats and high stepping on the compliant surface because reaching forward irritated her back.

Another potential weakness of the training sessions was the vast variability in amount assistance necessary for task completion of the three directly supervised activities. Some subjects only needed contact guard assistance or stand-by assistance, whereas other subjects required moderate assistance through the gait belt and/or hand holding for the reaching, turning in a circle and walking over the mat exercises. Subjects were also given different feedback based on the impairments noted while performing the activities. For example, one subject was continually told to put more weight through his forefoot while other subjects were not given this feedback. Also, despite literature that cites different outcomes on objective balance measures with different footwear, subjects were allowed to wear their typical daily footwear, because the authors deemed it to be the most functional approach.

As a potentially helpful factor, most subjects did not remember having taken the pre-test, thus, practice on the test was not a factor in improvements seen on the post-test. According to the authors’ visual observations, by the end of the final training session subjects appeared to be rising from the chair more easily without use of the armrests and they were stepping onto the pillows with greater assurance.
Since many of the weaknesses noted in this study concern the use of the FEMBAF, future studies could be conducted using a refined FEMBAF. A larger sample size may reveal a significant difference between the EC and EO groups following training. A similar study could be done using a different population, such as community-dwelling elderly or a population with specific impairments. Also, a follow-up study could use blindfolds that block subjects’ vision (including peripheral and downward) more completely and the subjects’ footwear could be monitored. In addition, another study could test subjects one or two months after the training sessions to determine how long the improvement in balance is sustained. Another consideration would be to monitor if improvements in balance correlate to a change in activity level or a decrease in number of falls experienced.

Our findings suggest that it is possible to improve a person’s balance in nine training sessions with general activities. Current literature indicates that task-specific training and balance treatments targeted at a person’s impairment yield significant results. It may be prudent for therapists to do some eyes closed training with their elderly clients to mimic functional activities in dimly lit environments, but if a client is too fearful of closing his/her eyes or of wearing dark glasses, then it appears that improvements in balance and mobility can be achieved without having to do eyes closed training. Furthermore, our findings suggest that an older person’s balance can be improved without the use of expensive equipment, rather common tools such as pillows (for a compliant surface), a chair and a mat with sandbags under it, can be used to achieve measurable gains.
Conclusions

There was a significant difference found between pre- and post- tests for subjects, however, no significant difference was found in FEMBAF scores between the EO and EC groups. These results do not support our hypothesis that balance training in the elderly will be more effective if done with eyes closed. These results imply that there is no benefit to training balance in the elderly with eyes closed vs. eyes open. However, before the authors’ hypothesis is dismissed a similar study with a larger population size should be performed. Another possible follow up study to this research is to gather normative data values for the FEMBAF based on subject’s age. Also, intrarater reliability studies on the FEMBAF need to be done to determine if this test is appropriate to be used as an assessment tool for research studies as well as in clinical settings.
Reference List


50. VanSwearingen JM, Paschal KA, Bonino P, Yang JF. The modified gait abnormality rating scale for recognizing the risk of recurrent falls in community-dwelling elderly adults. Phys Ther 1996;76:994-1002.


Appendix A
FEMBAF Part 1

Pretest/Posttest for Balance Training: A Comparison of Eyes Open and Eyes Closed Training Techniques

Modified Fast Evaluation of Mobility, Balance, and Fear (FEMBAF)

Name ___________________
Living situation: _____ at home
_____ assisted living
_____ retirement center
Lives: _____ alone
_____ with somebody

Age _____
Gender _____
Height _____
Weight _____

Risk Factors

1. Needs aid for two (or more) basic activities of daily living (washing, cooking, dressing, walking, continence, feeding) yes no
2. Needs aid for two (or more) instrumental activities of daily living (money management, shopping, telephone, medications) yes no
3. Has had a fracture or articular problems at hips, knees, ankles, &/or feet yes no
4. Has a visible articular condition in the hips, knees, ankles, &/or feet yes no
5. Uses a walking device (e.g., cane, walker) yes no
6. Limits physical activity to basic activities of daily living at home yes no
7. Self-defines as anxious yes no
8. Complains of vertigo yes no
9. Complains of imbalance yes no
10. Makes complaints suggesting an existing postural hypotension yes no
11. Fell one or two times in the current year yes no
12. Fell more than twice in the current year yes no
13. Required nursing after the fall yes no
14. Had a fracture after the fall
   
15. Is afraid of falling in general
   
16. Is afraid of falling indoors (e.g. bathtub, kitchen)
   
17. Is afraid of falling outdoors (e.g. bus, stairs, street)
   
18. Avoids going outside for fear of falling
   
19. Presents three or more somatic pathologies that require regular medical supervision (e.g. diabetes, high blood pressure, arrhythmia)
   
20. The pathologies require home-based medical-social supervision

21. Shows a specific pathology likely to induce falls:
   -- neurological (e.g. cancer, peripheral neuropathy, multiple sclerosis, lupus)
   -- cardiovascular (e.g., postural hypotension)
   -- musculoskeletal (e.g. total joint replacements, arthritis)
   -- sensory (e.g. visual impairment—cataracts, glaucoma, macular degeneration, retinopathy)
   -- other (amputation, Parkinson’s disease, Alzheimer’s disease)

22. Takes medications that are potentially dangerous in regard to falls:
   -- hypotensives
   -- neuroleptics
   -- hypnotics/anxiolytics
   -- antiarrhythmics
   -- antiparkinsonians
   -- analgesics/anti-inflammatory drugs
   -- various vasoregulators

Risk Factors (= total of “yes” answers): __________
### Appendix B
### FEMBAF Part 2

#### Task Completion

**Task Score (3, 2, 1)**

- **3** = successfully completed without imbalance;
- **2** = task initiated but unsteady or partially completed;
- **1** = unable to perform or initiate task

1. Sitting on a chair, with folded arms, raises both legs horizontally
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

2. Sitting on a chair with armrests, stands up without aid, without using banister
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

3. Sitting on a chair, stands up without aid, walks five steps, turns around, goes back and sits down
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

4. One-footed standing (left foot): stands on left foot without aide during **5 seconds minimum**
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

5. Repeat with one-footed standing (right foot)
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

6. Romberg Test: stands with heels together, eyes closed, remains steady for **10 seconds**
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

7. Squatting down: without aid, squats down until buttocks reach knee level, then stands up
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

8. Picking up a pencil from the ground without aid or support
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

9. Standing jumping without losing balance, over a distance equal to one’s own foot
   
   ____
   
   - fear  
   - pain  
   - mobility difficulties  
   - lack of strength

10. Stepping over an obstacle (foam or cardboard, 10 cm wide x 15 cm high) without touching it; the foot to arrive past the obstacle at a distance equal
to its own size (left)

_ _ _ _

11. Repeat with overstepping to the right

_ _ _ _

12. Shoving forward to trunk; subject to remain steady following a nudge
   between shoulder blades (examiner's arms stretched out, nudge realized
   by a sudden bending of hand on trunk)

_ _ _ _

13. Repeat with shoving backward (nudge on the sternum)

_ _ _ _

14. Climbing stairs without losing balance, without aid, or using banister
   (five steps minimum)

_ _ _ _

15. Repeat with descending stairs (five steps minimum)

_ _ _ _

16. Transfer from standing-kneeling (both knees on the ground); stable,
   no assistance for rising

_ _ _ _

17. Managing the “eyes-closed forward fall”; the subject lets himself/herself fall,
   eyes closed, onto the examiner standing 50 cm from him/her

_ _ _ _

18. Repeat with eyes-closed backward fall

_ _ _ _

FEMBAF TOTAL TASK COMPLETION SCORE:

(total possible = 54)

FEMBAF TOTAL SUBJECTIVE COMPLAINT SCORES:

_ _ _ _
Appendix C
Informed Consent Form

Pacific University

Title of the Project: Balance Training: A Comparison of Eyes Open and Eyes Closed Training Techniques.

Principal Investigators: Cara Carpenter, 846-9586, Megan O’Neill, 615-8598, Katie Putnam, 359-5548. Advisor: Dr. Laurie Lundy-Ekman, Ph.D., P.T, 359-2194

Location: Elderly residential and senior community centers in Washington county

Date: Summer 2000-Spring 2001

1. Description of the Project

This study is being done to compare the effectiveness of balance training with eyes open versus eyes closed. If you decide to participate in the study your balance ability will be tested using the Fast Evaluation of Mobility, Balance, and Fear (FEMBAF) before and after a 5 week balance training session. This test consists of two parts: 1) a questionnaire to be completed by you, addressing your mobility and balance ability and, 2) a task completion where you will be asked to do a number of activities including: one-foot standing, picking up an object from the floor, stepping over an object, and climbing stairs. You will have stand-by supervision for all activities during the FEMBAF. This test will take approximately 20 minutes. The balance training will consist of 20 minute sessions twice a week for 4 weeks. During each of these sessions you will be asked to perform a variety of balance exercises. These exercises will include: 1. Walking on uneven surfaces, consisting of a 10 foot long, thin firm mat with three or four small sand bag weights placed underneath 2. Turning in a circle while standing on a foam pad or pillow 3. Reaching out for an object while standing on a foam pad or pillow 4. Moving from sitting in a chair to standing 5. Side stepping at a counter or other support surface. You will perform these exercises in a circuit fashion with 30 seconds rest between each exercise and a 5 minute break between the 2 repetitions of the circuit.

2. Description of the Risks

When practicing balance activities there is the risk of falling. You could become nauseous or dizzy during the sessions. Because you are exercising you may also experience some mild muscle soreness as well as possible muscle strain. To minimize these risks, three experimenters will be present at all sessions to provide you with stand-by assistance in case you lose your balance or become unstable. You will also wear a belt which will be used by the experimenters to hold onto you should you experience loss of balance. If you feel nauseous or dizzy at any time during the training, you may
discontinue the training session. You will be instructed on proper stretching techniques to be used before and after the sessions to help reduce the risk of muscle soreness and/or muscle strains.

3. **Description of the Benefits**

From this testing we may learn more about your balance ability and how we can best improve your balance to possibly prevent any future disabling falls. Additionally, this study may be of benefit to others who may already have poor balance and are at risk for falling to learn how to best improve their balance. This study may also prove beneficial to other therapists concerned about improving balance in older people.

4. **Records**

Records for this project will be maintained in a confidential manner and no information concerning your identification will be released without your permission.

5. **Compensation and Medical Care**

If you are injured in this experiment, it is possible that you will not receive compensation or medical care from Pacific University, the experimenters, or any organization associated with this project. However, all reasonable precautions will be used to prevent injury.

6. **Offer to Answer any Questions**

The experimenters will be happy to answer any questions that you may have concerning this experiment at any time during the course of the study. If you are not satisfied with the answers that you receive, please call Dr. Daiva Banaitis, Director of the Physical Therapy School at 359-2160.

7. **Freedom to Withdraw**

You are free to withdraw your consent and to discontinue participation in this study or activity at any time without prejudice to you.
I have read and understand the above. I am 18 years of age or over.

Name (printed) ____________________________________________

Signed ________________________________________________

Date ____________________________________________

Address __________________________________________

Phone ____________________________________________

City __________________________________________

State/Zip ____________________________________________
### Appendix D

Raw Data

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Pre-test Score</th>
<th>Post-test Score</th>
<th>Difference Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>47</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>41</td>
<td>45</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>48</td>
<td>48</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>41</td>
<td>44</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>43</td>
<td>46</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>33</td>
<td>38</td>
<td>5</td>
</tr>
</tbody>
</table>

**Eyes Open**

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Pre-test Score</th>
<th>Post-test Score</th>
<th>Difference Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46</td>
<td>49</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>46</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>44</td>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>43</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>44</td>
<td>46</td>
<td>2</td>
</tr>
</tbody>
</table>

**Eyes Closed**

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Pre-test Score</th>
<th>Post-test Score</th>
<th>Difference Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>42</td>
<td>46</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>48</td>
<td>51</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>46</td>
<td>52</td>
<td>6</td>
</tr>
<tr>
<td>18</td>
<td>50</td>
<td>53</td>
<td>3</td>
</tr>
<tr>
<td>19</td>
<td>40</td>
<td>46</td>
<td>6</td>
</tr>
</tbody>
</table>