Environmental Illumination in Relation to Balance Performance in Healthy Community-Dwelling Elders

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ENVIRONMENTAL ILLUMINATION IN RELATION TO BALANCE PERFORMANCE IN HEALTHY COMMUNITY-DWELLING ELDERS

by

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Bachelor of Science in Physical Therapy
University of North Dakota, 1996

An Independent Study
Submitted to the Graduate Faculty of the Department of Physical Therapy School of Medicine University of North Dakota in partial fulfillment of the requirements for the degree of Master of Physical Therapy

Grand Forks, North Dakota May 1997
This Independent Study, submitted by Laura Christine Habermann in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Midun Fee)
(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title Environmental Illumination in Relation to Balance Performance in Healthy Community-Dwelling Elders

Department Physical Therapy

Degree Master of Physical Therapy

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Date 12-16-96
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ACKNOWLEDGMENTS

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to my family
ABSTRACT

The purpose of this study was to determine the effects low levels of lighting have on balance in healthy, community dwelling elders. The balance of 14 volunteer subjects (13 females and 1 male) who are older than 65, who live in the community and who are generally healthy was tested. Each subject's balance was tested in both optimal and poor lighting conditions using the functional reach balance assessment tool. Subjects were given two practice trials and were then instructed to reach three times in each condition while the researcher measured the amount of light in the room and the distance of their reaches. Results showed that the subjects reached significantly further, or had better balance, under the bright conditions. This finding may be used as supplemental information to fall prevention tactics used by clinicians and patients alike.
CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Falls are a common, yet serious occurrence in old age. Approximately one-third of community-dwelling elderly people older than 65 fall every year.\(^1\text{-}^3\) This age group accounts for only 12% of the U.S. population, but incurs 75% of deaths due to falls.\(^3\) Every fall has potential for serious physical injury or consequences. Five percent of falls in community dwelling elders will result in a fracture, and another 5% to 10% of falls will result in some other injury serious enough to require medical attention. One of every 40 fallers will be hospitalized and of those, only half will survive longer than a year after the fall. Not only do falls result in grave physical consequences, but also in more indirect psychological consequences of falling, such as "fallaphobia," the disabling fear of falling. Both elderly fallers and nonfallers alike can be so afraid of falling, that they place self-imposed restrictions on their mobility to avoid falls.\(^4\text{-}^5\) Immobility can, in turn, lead to joint contractures, deep vein thrombi, pressure sores, urinary tract infections, muscle atrophy and loss of functional independence.\(^5\text{-}^6\)

Recurrent fallers who have declined in their abilities to function independently are more likely than non-fallers to be admitted to a hospital\(^7\) or long term care facility.\(^8\) In fact, falls are a contributing factor in 40% of all nursing home admissions.\(^9\)
One can easily understand the numerous implications falls in the elderly have, including a compromised quality of life, needless time spent in pain and suffering, and burdensome medical costs to both the elderly and to society. The sad irony of this situation is that many debilitating falls could have been prevented if the offending agents, or the causes, had been identified sooner. Because there are so many risk factors that lead to falls, identifying which ones play a part is not always a simple task. Each potential faller is at risk because of a set of factors unique to that individual. Much research classifying probable risk factors for falls has been conducted.\textsuperscript{4-6,8-15} These risk factors can be divided into two categories: intrinsic and extrinsic risk factors.\textsuperscript{5,16}

Intrinsic Risk Factors

Intrinsic fall risk factors are those that reside within a person to put them at greater than average risk for falling.\textsuperscript{5,16} Age related changes, pathological processes, certain medications, cognitive impairments, and balance disorders are just a few of these intrinsic risk factors.

Although many intrinsic risk factors for falls have been investigated, perhaps none more so than impaired balance. Numerous studies have found that balance deficits are important risk factors for falls.\textsuperscript{5,6,9,11,17,18} Fallers are more likely to have significantly poorer balance than non-fallers.\textsuperscript{19-22} Understanding why, when and how balance is lost helps one understand the circumstances under which falls occur, so that these falls may be prevented.
Because a fall can be seen as a loss of balance that causes one to land on the floor or some lower surface, many of the causes of falls are essentially identical to the causes of impaired balance.

A multitude of pathologies, injuries, medications, etc. can adversely affect balance, as seen in frail elderly.\textsuperscript{23,24} However, many relatively healthy elderly people who do not suffer from any pathologies, injuries, or adverse medicinal side effects still have poorer balance and fall more frequently than their younger counterparts. This occurrence is most likely explained by naturally occurring age-related changes in the human sensory systems.

To understand how those changes affect balance, one must know what balance is and how the senses contribute to the maintenance of balance. Postural control, or balance, is an extremely complex process in the human body. Proper static and dynamic balance are the partial result of the integration of vestibular, proprioceptive and visual input.\textsuperscript{22,25} The successful integration of this input results in maintenance of an upright posture, with the body's center of mass within its base of support and with only a minimal amount of sway; however, naturally occurring age-related declines in each of these systems, which may lead to balance impairments and falls, have been shown to occur even in healthy elderly people.\textsuperscript{26,27}

Vestibular Component

The vestibular system senses change in acceleration and deceleration forces acting on the head. It references the position of the head to gravity,
thereby contributing to the vestibular ocular reflex and to the labyrinthine righting reflex. The righting reflexes, which help the body to maintain its balance during sudden displacements, originate within the semicircular canals of the labyrinth in the inner ear.\textsuperscript{28} Vestibular information is especially important in maintaining balance when visual or proprioceptive input is limited.\textsuperscript{6,28,29} Unfortunately, the righting reflexes diminish with increasing age. Although the exact age-related changes that occur within the vestibular system are controversial, perhaps some of the loss of the righting reflex can be attributed to changes in the hair bundles and loss of sensory cells, as found by Rosenhall and Rubin.\textsuperscript{27}

Proprioceptive Component

Proprioception, one of the other two key senses needed for balance, is important in minimizing body sway.\textsuperscript{30} Input from the cervical mechanoreceptors aids the neck, extremity, and eye muscles in maintaining an upright posture.\textsuperscript{6} A loss of proprioception is seen in these receptors as well as in the receptors in the lower extremities of the elderly.\textsuperscript{6,31} The thresholds for excitability of position sense receptors increase with age. Because of this proprioceptive loss, elderly people may increasingly rely on their other senses, such as vision, to maintain their balance.

Visual Component

Vision, the third sense important for balance, is also not spared from the detrimental effects of aging. As the eye ages, it undergoes changes that impair one's ability to accurately perceive the environment. Visual acuity, or the eye's
ability to see details, declines with increasing age. Only 14% of those older than 80, and 25% of those aged 70 to 79 years have normal levels of visual acuity. Visual acuity worsens as the pupils of the eyes decrease in size with age, restricting the amount of light able to reach the retina. As a result, elderly people are less likely to accurately see objects and details in their environments. Visual acuity is worst under low levels of lighting. For every 13 years of adult life, the human eye needs about twice the amount of illumination for the same level of visual acuity that young adults have under low levels of lighting.

Elderly people are also more sensitive to glare and bright light than younger people. A multitude of physiological explanations for this phenomenon have been given, including a slower pupillary response. The pupil normally constricts quickly as the eye is exposed to sudden intensification in light. With age, the pupil reacts more slowly and lets too much light in, producing glare.

In addition to the above changes, elders gradually lose their ability to accommodate, or focus on nearby and moving objects. This task relies on the strength of the ciliary muscles and the flexibility of the lens, both of which diminish with age.

Depth perception begins to decline quickly during middle age. When depth perception is affected in elderly people, it becomes more difficult for them to recognize objects of varying height and shape, especially when the objects are similar in color. Because of this, environmental objects such as stairs,
door sills, and uneven ground become hazards. When these objects are under dim light, the problem is even compounded.

A person's visual field naturally shrinks, particularly after the age of 75. Because of limitations in eye movement, a diminished upward gaze, senile ptosis of the upper eyelids, and recession of the eyeball into the skull as the retrobulbar fat atrophies, elderly persons' vision becomes narrower in all directions, resulting in tunnel-like vision. Older persons are less likely to see hazardous objects outside of their narrowed visual fields, which further increases their risk of falling.

Visual threshold is the term used to describe the minimum amount of light the eye can perceive and the ability of the eye to adjust to variable lighting levels. It includes the eye's ability to adapt to both low levels of lighting and extreme brightness. The eye's ability to adapt to low levels of illumination depends on the adaptability of the iris. As the adaptability diminishes, as with aging, the iris lets less light in and the person has a more difficult time seeing objects in darkness or areas of dim lighting.

Lastly, color perception is affected by the aging process as well. As people age, the lenses of their eyes become less transparent and more yellow in color. The yellowed lens filter out green, blue and violet colors before they reach the retina. Greens and blues become harder to distinguish, whites look more yellowish, and all colors' relative brightness becomes harder to detect. Under low levels of lighting, this problem is magnified. Objects tend to look more similar in color, which leads into a problem with depth perception.
To summarize, all of the sensory systems are adversely affected by age. Age-related postural imbalance, an important intrinsic fall risk factor, has been associated with these visual, vestibular and proprioceptive losses. Visual acuity, contrast sensitivity and peripheral vision have each been shown individually to be important in maintaining postural stability. When they are reduced, sway, a measure of postural stability, increases.

Extrinsic Risk Factors

Although poor balance is an important and prevalent fall risk factor in healthy elderly people, one must not forget the many extrinsic fall risk factors that they encounter every day in their homes. Extrinsic risk factors are either objects in one’s environment such as throw rugs, clutter, and slippers or they are improper conditions, such as inadequate lighting in an area. Numerous studies have documented the incidence of falls related to these environmental conditions, or extrinsic risk factors. Lucht found that poor lighting is the direct cause of 4.6% of all falls and accounts for 12% of all extrinsically-related falls. Wild reported that 19.2% of all falls occur in darkness or in dimly lit areas. Authors have confirmed lighting’s importance in preventing falls by giving specific suggestions for improving lighting conditions in the residences of elderly people. For example, guidelines given by the Illuminating Engineering Society recommend that people over 55 need at least
20 foot-candles in corridor or restroom areas, whereas those younger than 40 need only 10 foot-candles to see in those same areas.\textsuperscript{53}

**Interaction between Intrinsic and Extrinsic Fall Risk Factors**

Understanding the interaction between intrinsic and extrinsic fall risk factors is critical to comprehending how falls occur. Most falls result from the cumulative affects of both intrinsic and extrinsic factors.\textsuperscript{26} Intrinsic risk factors can make a person more susceptible to being overcome by extrinsic risk factors. Conversely, a person possessing few intrinsic risk factors is less likely to be affected by the extrinsic risk factors in his or her life. According to the Hindmarsh and Estes\textsuperscript{52} "threshold" theory, falls most often cannot be blamed on singular causes; rather, falls occur when a combination of factors accumulate to a point at which the person can no longer maintain adequate postural stability. Any risk factor beyond the threshold, no matter how small, will result in a fall. Such is the typical case when an 85 year old woman arises in the middle of the night to use the bathroom. Although she is healthy, she has trouble seeing in the dark, and her poorly lit room only makes matters worse. This mixture of intrinsic and extrinsic risk factors causes her to fall once any additional hazard such as an obstacle in her pathway is introduced. Perhaps a younger person in the same situation would have been able to see more accurately in the dark and would have avoided the fall or recovered from a loss of balance; or, perhaps that same older woman in a well lit room, without clutter would also not have fallen.
In order to prevent falls, one must realize how age-related sensory changes affect a person’s ability to interact with her environment. As in the above example, age-related sensory changes, which can cause poor balance, may impair one’s ability to perceive extrinsic risk factors correctly and could lead to a fall. Vision is one of the most relied upon senses for maintaining balance, but it’s also among the most detrimentally affected senses by the aging process. Because of these changes, elderly people do need at least twice as much illumination than young people to perceive their environments correctly. In particular, visual acuity, depth perception, visual threshold, and color perception are adversely affected by low levels of lighting. It is well established that vision is important in balance control and individually, poor lighting and poor balance are each well established fall risk factors. It makes sense that these two risk factors should go hand in hand: poor vision or lack of visual input worsens balance, leading to falls, and already poor vision becomes even worse in conditions of dim lighting. Therefore, it is hypothesized that inadequate lighting could worsen balance in healthy elderly people.

Although many studies have tested balance in elderly people under conditions of occluded or distorted vision, no studies have researched the effects lighting has on balance in elderly people. In this most recent era in health care, emphasis has been placed on using measurement tools that are
functionally based. When balance is tested in conditions of total darkness or total visual occlusion, typical conditions really are not simulated. Even elderly people are able to perceive some, albeit little, light during the night even without any lights on. Conditions of complete darkness are actually quite isolated, but conditions of dim lighting, on the other hand, occur every day. One must reflect on the daily activities that a healthy community dwelling elder encounters to discover the prevalence and significance of this situation. Between 80% and 90% of elderly people experience nocturia, and it cannot be assumed that all people use sufficient lighting when they do get up at night. People who arise two or more times during the night are significantly more likely to fall when compared to those who get up zero to one times each night. Even if they do use lights when they get up, the lighting may be dim and yellow at best, as it is with night lights.

Age related visual changes only make any existing problem of inadequate lighting worse. Through the eyes elderly people, the world appears less clear, less bright, and more yellowed than the world that younger people see. The ground is harder to see, obstacles blend into the shadows, and uneven surfaces appear to be even. To a young person, a dim hall light may be of no consequence, but to an elderly person, poor lighting could be the factor that surpassed the threshold of postural control, resulting in a fall. That fall, which could have been prevented, will end up causing pain, diminished self-confidence, and perhaps thousands of dollars. The purpose of this study is to
determine if low levels of lighting do affect balance in healthy elderly persons. It is hypothesized that balance performance will be significantly poorer in conditions of low lighting. This knowledge may then assist health care providers in supplying the elderly and clinicians with accurate fall prevention and home safety instructions.
CHAPTE II

METHODS

Subjects

Volunteers were recruited from a local community housing complex for people older than 55, from an aquatics exercise program, and by word of mouth. Inclusion criteria included: age over 65, absence of any recent (within the last year) neurological or orthopedic impairment, current absence of dizziness, accurate vision with current corrective devices, ability to walk unassisted and stand unsupported, intact great toe proprioception, ability to raise the arm to 90 degrees flexion, and absence of balance problems caused by current medications. Subjects were excluded if: they didn’t meet one or more of the above criteria, if they had pain with less than 90 degrees of shoulder abduction or flexion, pain or less than full range of motion in elbow extension, asymmetrical neurological responses, or abnormal tone in the upper and lower extremities.

Seventeen subjects (15 females and 2 males) participated in this study. Data from two of the subjects (1 male and 1 female) were excluded because of the subjects had uncorrected visual deficits. Data from another female was excluded because she was unable to walk unassisted. Ages of the subjects (n = 14) ranged from 68 to 90 years with a mean of 75.93 years. (Table 1) Heights in
Table 2.—Subject Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 14)</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>75.93</td>
</tr>
<tr>
<td>SD</td>
<td>7.19</td>
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<tr>
<td>Range</td>
<td>68 to 90</td>
</tr>
<tr>
<td>Height (inches)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>63.75</td>
</tr>
<tr>
<td>SD</td>
<td>2.58</td>
</tr>
<tr>
<td>Range</td>
<td>59.5 to 70</td>
</tr>
</tbody>
</table>
inches ranged from 59.5 to 70 inches with a mean of 63.75 inches. Subjects were informed of the purpose of the study and of the testing procedure prior to testing. Each subject read and signed an informed consent form approved by the University of North Dakota Institutional Review Board (Appendix A). Data from three subjects were excluded because these subjects did not meet predetermined selection criteria. All people, including those whose scores were omitted, were tested to provide the researcher with the maximal amount of potentially useful information.

Instrumentation

The functional reach (FR) test developed by Duncan et al\textsuperscript{55} was used to assess balance. This test has demonstrated excellent test-retest reliability, concurrent validity, criterion-related validity, interrater reliability, construct validity and predictive validity for falls.\textsuperscript{55-59} The FR is an inexpensive test and is easily performed in a short amount of time (less than 10 minutes). Prior to testing, the principle researcher practiced the FR on 19 fellow students to become adept and reliable.

Functional reach is a clinical balance measure that represents the distance one can reach forward in a horizontal plane while maintaining a fixed base of support in standing.\textsuperscript{55} The FR tests balance in the sagittal plane. It is one of the few clinical balance tests that measures dynamic balance skills rather than static skills, which are tested by other clinical measures such as the
Romberg test. Dynamic balance skills, by nature, are more functional and more representative of one's actual abilities.

Instruments used in this study were a 48 inch long measuring stick with a level built into its center, two 4 watt/125 volt night lights, and a Sylvania GTE™ light meter. The light meter measures illumination in a room to the nearest one-tenth of a foot-candle, and the minimum amount of light it can detect is 0.1 foot-candles (fc). Two similar rooms were used for the testing procedure: one was the chapel in a local retirement complex and the other was an exam room in a local hospital. All windows, mirrors and reflective structures in the rooms were covered. Walls were a neutral white color and the floors were light beige tile. Two nightlights were placed within ten feet of the subject, each in a separate outlet. Chairs were provided for subjects to sit on while questionnaire and screening procedures were being administered.

Procedure

Subjects signed an informed consent form and were then evaluated on site. Answers to inclusion and exclusion criteria included in a brief medical history form along with any history of falls were recorded and discussed. (See Appendix B for a copy of the complete questionnaire and data collection forms.) The data of only those subjects (n=14) who met inclusion criteria were used to obtain the results. A brief physical screening was performed to rule out any confounding orthopedic or neurological impairments. Active shoulder and elbow
range of motion were tested with the subject sitting. To be included, the subject had to demonstrate 90 degrees of painless shoulder flexion and zero degrees of painless elbow extension. The neurological component of the exam included tests of the biceps, patellar tendon and Babinski reflexes, coordination (heel-knee-shin and finger to nose), great toe proprioception, and tone in the upper and lower extremities. Only data from subjects with normal orthopedic and neurological exams, as given in the criteria, were included in this study. These screening criteria were nearly identical to the criteria Duncan et al\textsuperscript{55} used in their initial study of functional reach.

The heights of the subjects were measured without their shoes on while standing with their backs against the wall to which a yardstick was mounted. A ruler was placed on top of their heads and parallel to the floor. With the examiner at eye level, the subjects' heights were measured, rounded off to the nearest 1/2 inch and recorded.

Functional reach was measured using a 48 inch measuring stick. The measuring stick was horizontally mounted on the wall so that its top edge was at the height of the subject's acromion when the subject had no shoes on. The test was explained verbally to each subject and was then physically demonstrated by the researcher. Subjects were instructed to stand with their feet shoulder-width apart and with the lateral aspects of their right arms approximately three inches from (perpendicular to) the wall. Light et al\textsuperscript{59} recommended placing the subjects
this close to the wall to avoid binocular parallax errors. Their feet were aligned with long piece of tape on the floor so that the distal ends of their great toes touched the far edge of the tape. The exact same standing position was used for all trials. Subjects were asked to make fists with their right hands and then raise their right arms forward to a 90 degree angle (shoulder level). The shoulder was perpendicular to the measuring stick and the third metacarpal was at the same level as the measuring stick. Subjects were advised to not protract or retract their shoulder when achieving this starting position; their position was visually inspected to confirm a correct starting position. The researcher stood exactly perpendicular to the beginning placement of the third metacarpal aligned with the measuring stick and then recorded this position. Each time subjects were given the instructions to "Reach as far forward as possible with your arm without losing your balance or taking a step." The researcher stood approximately three feet from the subject to avoid resolution discrepancies in measurement as recommended by Light et al. The position of the third metacarpal along the measuring stick was again recorded in same way it was recorded in the starting position. The upper extremity was not allowed to touch the wall at any point and the left arm was required to stay by the subject's side. If subjects violated any of these rules, took a step or lost their balance, the trial was repeated. In this manner, subjects performed two practice trials. After the practice trials, subjects picked a card which had “bright” or “dim” written on the
through this system, trials were randomized to reduce practice effects on the data.

Conditions

Balance was measured in two different conditions: 1) in a bright room lit by fluorescent ceiling fixtures and 2) in a dim room lit only by two night lights. Adequate lighting was defined by the Illumination Engineering Society’s standards which say people older than 55 require 22 fc for general lighting in office, corridor and restroom areas.\textsuperscript{53} In the rooms where balance was tested, the average amount of illumination was 36.57 fc (range 29.0 to 49.6 fc; SD 4.03fc) with the lights on. Dim lighting was defined as illumination levels less than 5 fc, as given by the Illumination Engineering Society’s standards.\textsuperscript{58} The average amount of illumination in the dim lighting condition was 0.1 fc (range 0.1 to 0.1; SD 0). No data could be found that gives the recommended amount of home lighting for elderly persons.

Trials were randomized by having subjects blindly select a card which represented the lighting condition. Subjects stood between 3 to 10 feet away from the light source. Illumination was measured by placing the light meter at the same level and pointed in the same direction the subjects’ eyes looked. Subjects were given three minutes or as much time as they felt they needed to adjust to the new lighting situation. A research assistant stood within two feet behind the subjects to guard against falls. The subjects then reached three
times in a row in each condition. Distance in reach to the nearest half inch was recorded. Reach strategy was not controlled for, so long as the subjects did not touch the wall, lose their balance or take a step.
CHAPTER III
STATISTICAL ANALYSIS AND RESULTS

Statistical Analysis

Subject age means and height means were calculated. The final reach point on the stick was subtracted from the starting reach point on the stick to determine the length of reach in each trial and in each subject. Means of the three trial reaches in each condition were computed for all subjects. These means were used to compute the $t$ statistic for related samples, which was used to assess the relationship between functional reach scores (distance of reach) and lighting condition. Distance reached represented one variable (x) while the lighting condition represented another (y). Statistical analysis was two-tailed and the level of significance was set at ($p < .05$). Statistical analysis was performed using SPSS-X™.

Results

A related-samples (repeated measures) $t$ test for the 14 pairs was computed to determine whether reach distance in the dim condition was significantly different than distance reached under the bright condition. This test found that subjects reached significantly further ($p = .022$) under the bright conditions. Means of reach scores were also computed for each condition.
Subjects reached an average of 11.6071 inches (SD 2.860) under the bright condition and 10.8692 inches (SD 2.837) under the dim condition. Table 2 shows additional statistical details that will not be discussed further here.
Table 2.—Results of t Test for Related Samples

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
<th>SE Mean</th>
<th>t value</th>
<th>95% CI</th>
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<tr>
<td>Bright</td>
<td>11.6071</td>
<td>2.860</td>
<td>.764</td>
<td>2.59</td>
<td>.022</td>
</tr>
<tr>
<td>Dim</td>
<td>10.8692</td>
<td>2.837</td>
<td>.759</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER IV
DISCUSSION

Related samples $t$ statistic values indicated that functional reach scores were significantly shorter when subjects were tested in a dimly lit room. These results tend to support the hypotheses that balance in elderly people is worse under conditions of inadequate lighting. A possible explanation for this finding involves the normal age related visual changes all people experience. Visual acuity, depth perception, visual threshold and color perception are all adversely affected by the aging process and are worsened even more under low levels of lighting.\textsuperscript{6,28,35,58,41,44} Elderly people need at least twice as much illumination as young people do in order to see as accurately under the same lighting conditions. This decline in visual function can be of great consequence to the elderly person; vision is an extremely important component of balance control, and adequate balance control is key to preventing falls.\textsuperscript{48} Although many studies have linked poor vision, poor balance and poor lighting to falls, none to date have documented the effects lighting conditions have on balance.

In the home environment, elderly people frequently move about in dimly lit areas. Of the subjects used in this study, only 35.7\% turned on their lights when they arose in the middle of the night. Approximately 29\% used no lights or relied upon
night lights, and two subjects (14.3%) turned on the lights only occasionally. The other three subjects (21.4%) did not answer the question. Even standard night lights, such as the those used in this study, do not emit enough light to adequately illuminate a room for safe ambulation.

As physical therapists, we can do nothing to directly slow or prevent age related changes in vision, but we do have a role in preventing falls. If balance is significantly worse in conditions of dim lighting, we must educate our patients on the relationship between balance and falls, and on the importance of good lighting in fall prevention and balance training. By eliminating poor lighting as a risk factor for postural dyscontrol and falls, the elderly person's threshold for falling will naturally be lowered. That is, if the lighting is adequate, more factors must again accumulate to a certain level before that person will lose his or her balance and fall. Preventing falls could save millions of dollars spent on treatment, eliminate needless pain and suffering, and prolong the excellent quality of life enjoyed by thousands of elderly people every day.

The hypothesis of this study stated that balance is worse under conditions of dim lighting. To reiterate, the reasons for this hypothesis are five-fold: 1) Vision becomes worse with age, especially in poor lighting. 2) Studies have shown that when vision is occluded or distorted, balance is worse. This shows that our visual sense is important in balance. 3) Poor balance is one of the top fall risk factors. 4) Dim lighting is, in itself, a fall risk factor. 5) Dim lighting should
cause poor balance because vision is worsened (functionally distorted) in conditions of poor lighting.

Of course, worsened vision under dim lighting may not be the sole factor or even a factor causing these lower functional reach scores. It is possible that because subjects were not blinded as to the purpose of the study, they subconsciously reached further under the bright conditions to please the researcher. This same effect could also have resulted from the researcher not being blinded to the purpose of the study.

Subjects could have been more fearful of falling in the darkened room, or perhaps their eyes had not yet fully adjusted to the lighting condition when they were tested. For those who reached in the dim condition first, maybe their soft tissues were more relaxed or maybe they had developed a more effective reach strategy by the time their reach was tested in the bright condition. Conversely, perhaps those subjects who were tested first in the bright room became fatigued and weak by the time they were tested in the dim room. Either of those situations could have caused reach scores to be less in the dim condition. In addition, the lack of a standard testing room (two were used), the small sample size and the researcher’s lack of experience all could have been factors limiting the value of this study.

Because of these numerous limitation, the results of this study must be interpreted with caution. The use of a different balance test, a more experienced
researcher, a larger sample size, a standardized testing room and a double-blind research design are recommended improvements to this study and may or may not yield different results.

Future research should aim at eliminating the limitations present in this study. Sample size should exceed 30 subjects for the data to be truly significant. The researcher should be well versed and practiced on the functional reach or on another valid and reliable balance testing instrument. In addition, a double-blinded research design that uses an independent sample t test would yield the most useful and sound evidence either supporting or rejecting the hypothesis presented in this paper. Future research could also delineate the amount of illumination elderly people need before their balance begins to decline, explore what other extrinsic factors worsen balance, and compare the balance of young and old people under dark conditions.
CHAPTER V

CONCLUSION

Assessing and treating balance dysfunction in elderly people is a very important part of fall prevention tactics that physical therapists use; evaluating and modifying the home environment is another critical component. Many elderly people use night lights in their homes to help prevent losses of balance and falls from occurring during the night; however, no studies to date have validated the thought that night lights, do indeed, emit an adequate amount of light for accurate vision and, hence balance control. This study investigated the effects dim lighting (as produced by two night lights) has on balance in healthy elderly people who live independently in the community. Results showed that in the 14 subjects studied, balance was significantly worse (p<.05) in dim conditions when it was measured by the functional reach balance test. This finding supplements and verifies knowledge clinicians have about improving balance and preventing falls in the healthy elderly population.
APPENDIX A
The above referenced project was reviewed by a designated member for the University's Institutional Review Board on September 19, 1996 and the following action was taken:

☑ Project approved. EXPEDITED REVIEW NO. 3
☐ Next scheduled review is on September 1997

☐ Project approved. EXEMPT CATEGORY NO. ____ No periodic review scheduled unless so stated in REMARKS SECTION.

☐ Project approved PENDING receipt of corrections/additions in ORPD and approval by the IRB. This study may NOT be started UNTIL IRB approval has been received. (See REMARKS SECTION for further information.)

☐ Project approval deferred. This study may not be started until IRB approval has been received. (See REMARKS SECTION for further information.)

☐ Project declined. (See REMARKS SECTION for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairman or ORPD.

cc: M. Green, Adviser

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 596 Form may be required. Contact ORPD to obtain the required documents.
The purpose of the proposed study is to determine the effects low levels of lighting have on balance in healthy community dwelling elders. The balance of 20 volunteer subjects who are older than 65, who live independently in the community and who are generally healthy, will be tested. The subjects will be recruited from local community housing developments for seniors. Specific inclusion criteria regarding health status must be met by each participant. Each subject's balance will be tested in both optimal and inadequate lighting conditions using the Functional Reach Test. Presently, there is a paucity of research relating low levels of lighting and poor balance in elderly people. Results from this study may be used by clinicians to instruct elderly persons in fall prevention and home safety. Measuring functional balance under conditions of varying lighting is only feasible on humans and results are applicable to humans only.
2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

BACKGROUND AND OBJECTIVES:
Falls are a serious, yet common occurrence in elderly people who live independently in the community. Low levels of lighting and poor balance both have been shown to be important risk factors for falls. It is well known that elderly people require more illumination than young people for correct visual acuity. Many suggestions have been made regarding the prevention of falls through improvement of home lighting conditions, but it is not known whether lighting conditions affect balance. It is known that vision is very important in the maintenance of balance, but research reports relating vision to balance have been done in conditions of absent or distorted vision. No researchers have studied the effects low levels of lighting have on balance. Because elderly humans frequently function in conditions of dim lighting it is essential to know if any of these conditions adversely affect or improve balance. With this knowledge, healthy elderly persons will be able to more effectively prevent losses of balance in their home environments; health professionals will be able to supply the elderly with accurate advice on fall prevention; and physical therapists will be able to train balance in the elderly under more optimal conditions.

SUBJECTS: 20 independent elderly subjects over the age of 65 will volunteer to participate in this study. All subjects must be healthy. That is, they must meet specific inclusion criteria given in the attached questionnaire. The principle researcher will recruit subjects from local senior citizen centers and from local senior housing developments by posting invitational fliers. Subjects will be recruited for three months at the most, or until at least 10 appropriate subjects have been recruited. Each subject will be informed of the purposes, procedures, potential risks and benefits of the study, and will sign a statement of informed consent.

INSTRUMENTATION:
The functional reach test is both a reliable and valid measure of balance. An instrument is considered reliable if similar results are found between two or more testers (intrarater reliability) and in consistency is shown through repeated measurements by one tester (intrarater reliability). A practice session conducted by the project leader and two other clinicians affirmed good intrarater and intrarater reliability. Criterion-related validity of the functional reach test has been established using center of pressure exertion and videotape analysis as standards for comparison. The functional reach test's concurrent validity was established through its association with lifespace (a social mobility measure), a mobility skills protocol, 10 foot walking speed, one leg standing and tandem walking.

PROCEDURE:
Balance will be measured under the following conditions: 1) In a poorly lit room without shoes on and 2) In a well lit room without shoes on. On the wall a 48 inch level measuring stick provided by the researcher will be mounted at the acromion height of each respective subject. The floor will be level. Walls will be a neutral color and no distracting visual or aural input will be present in this room. The room will contain no windows or mirrors. The lighting conditions will be identical for all subjects and will be measured each time by a light meter placed one foot away from the from the yardstick on the wall to assure consistency. The subjects will first receive verbal and demonstrative instructions of the procedure. Research shows that the elderly learn most effectively through multisensory strategies. After the demonstration, the subjects will assume a comfortable stance three inches next to the yardstick on the wall. The subjects will then be asked to reach as far forward as possible without taking a step or touching any surface with their upper torso or extremities. Instructions will be given in lay terms and will be repeated identically with each subject and with each trial. The subjects will perform two practice trials and then three trials in each condition to assure they fully understand the instructions, to decrease the chance of trunk rotation and to minimize any learning effects. The order of the conditions tested will be randomized to help control learning effects. The distance, in inches, of each trial will be recorded by the researcher. The mean of the three trials in each condition will be expressed as the results. The order of the conditions will be randomized to further minimize the effects practice might have on outcomes. Subjects will be given adequate time between test conditions to adjust to the change in lighting conditions. An assistant to the project leader will stand nearby to safeguard the subjects from falling in the event that they would lose their balance. The project leader will be responsible for all other project related duties. Each trial will take approximately 10 seconds. Subjects will be allowed to take as much time as they need between trials and test conditions. Total time involvement will be approximately 10 minutes per subject. Mean values will be calculated at a later time.

The movements required to complete the functional reach test are expected to be painfree. If pain is produced or present during the testing, the subject will be excluded from the study. Subjects will also be excluded from the study if they are suffering from any new illness, of if at any time, they do not meet all of the criteria set forth in the questionnaire. Each subject is free to decline participation in this study at any time. Statistical analysis of this study will include a comparison of means between test conditions and a calculation of variance and mode for any detected skewness. A related samples t-test will be the most appropriate statistical method for the design of this research project. All data and copies of this research project, including consent forms, will be kept in a confidential file by Meridee Green, MPT, in the department of physical therapy at the University of North Dakota. Here they will remain for a two year period.
3. **BENEFITS:** (Describe the benefits to the individual or society.)
The individuals in this study will benefit by knowing whether their balance is affected by dim lighting. They will also gain knowledge of how their balance compares to others that have been previously tested with the functional reach. The data that will be collected will especially benefit physicians, physical therapist, and other health care professionals who seek to improve balance and prevent falls in the elderly. Studies have found that postural imbalance is one the key factors that put many elderly at risk for falls. By collecting data on the environmental conditions that may affect balance in the elderly, physical therapists can treat balance disorders under optimal conditions and give their patients more accurate advice regarding the prevention of falls.

4. **RISKS:** (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psycho-logical, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

There are only minimal risks to the individuals participating in this study. The functional reach test is a simple and safe test of balance. Subjects will stand in a comfortable position and reach as far forward as possible with their arms, as this distance is recorded. This motion is one that is performed routinely in daily life. The conditions the test is performed under are also normally encountered in daily life. The risks involved are minimal because of this. In the event that a subject loses his or her balance, an assistant will be standing close enough to the subject to guard the subject from falling. Subjects will be given adequate time to accommodate to the lighting conditions of the room. Also, this balance test will be demonstrated to them before their balance is tested. The subjects are voluntary participants, who will be chosen based on their ages, health status, and willingness to participate as indicated by a signed consent form. These volunteers may withdraw at any time without fear of retribution or prejudice. Data will be assigned a number corresponding to the subject, so that no subject can be personally identified.
5. **CONSENT FORM:** A copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

A copy of each consent form, along with all questionnaires and data forms, will be maintained in a file kept by Meridee Green, MPT and instructor, in the department of physical therapy, room 2542. These will be kept confidential and will be stored at this site for a two year period.

6. For **FULL IRB REVIEW** forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development  
University of North Dakota  
Box 8138, University Station  
Grand Forks, North Dakota 58202

On campus, mail to: Office of Research & Program Development, Box 134, or drop it off at Room 101 Twamley Hall.

For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

**SIGNATURES:**

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Principal Investigator  
DATE: ______________

Project Director or Student Adviser  
DATE: ______________

Training or Center Grant Director  
DATE: ______________

(Revised 8/1992)
INFORMATION AND CONSENT FORM

TITLE: Environmental Illumination and Balance in Healthy Community Dwelling Elders

You are being invited to participate in a study conducted by Laura Habermann, a graduate student in physical therapy at the University of North Dakota. The purpose of this study is to study how low levels of lighting affect balance in healthy elderly people who live independently in the community. The results of this study may contribute to the improvement of balance and prevention of falls in elderly people. Only normal, healthy subjects will be asked to participate in this study.

Your balance will be tested under two different conditions: once in a well lit room and once in a room lit only by a night light. Before your balance is tested, the test will be explained and demonstrated to you. You then be able to practice the test twice. The test simply requires you to stand normally, without your shoes or socks on and reach forward as far as you can without taking a step or touching the wall. The distance you reach will be recorded each time. You will always be given enough time to adjust to the light in the room, and an assistant will always stand by you in case you lose your balance. This whole testing procedure should take no longer than ten (10) minutes.

When performing any physical task, there is always some risk of injury. However, we feel the risks involved with this study are minimal. Any risks will be lessened by allowing you adequate time to adjust to different lighting conditions and by safeguarding you from falling with the help of an assistant. In the unlikely event that this balance testing does result in injury, you will be given the same opportunities for medical assessment and treatment as the general public. The University of North Dakota policy states that any follow-up medical treatment must be paid for by you or your third-party payer.

Your name will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. The data will be identified by a number known only by the investigator. The investigator or participant may stop the experiment at any time.
if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department or the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without prejudice.

The investigator involved will be happy to answer any questions you have concerning this study, now or in the future. Questions may be asked by calling Laura Habermann or Meridee Green, physical therapist and instructor at the University of North Dakota at 777-2831 or 777-9173 (Laura’s Home Number). A copy of this consent form is available to all participants in the study.

ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE CONCERNING THIS STUDY IN THE FUTURE. MY SIGNATURE INDICATES THAT, HAVING READ THE ABOVE INFORMATION, I HAVE DECIDED TO PARTICIPATE IN THE RESEARCH PROJECT.

I, ________________________, have read all of the above and willingly agree to participate in this study explained to me by Laura Habermann, graduate student in physical therapy.

______________________________
Participant’s Signature Date

______________________________
Witness (not the scientist) Date
APPENDIX B
QUESTIONNAIRE

I will be asking you some general questions about your medical history. Please respond to these questions as best you can. If you have trouble understanding these, please let me know and I will be happy to repeat the question. If you have any other questions, please do not hesitate to ask me. All of your answers will remain confidential. You are free to withdraw at any time and for any reason. This information will help me decide who is eligible to be included in this study.

1. What is your date of birth?

2. Are you left handed?

3. Have you had any surgeries or fractures in the last year?

4. Have you ever been diagnosed with a neurological condition such as a stroke, Parkinson’s disease, etc.?

5. Have you ever had a vestibular disorder such as Meniere’s disease, or anything else that could cause dizziness?

6. Have you ever been diagnosed with or suffered from any visual conditions?

7. How would you describe your vision when you are using any lenses you may or may not normally use?

8. Briefly, will you tell me anything about your medical history that I have not asked about, including diseases, conditions, injuries, and hospitalizations?

9. Do you take any medications besides vitamins or over-the-counter pain relievers?

10. If so, which medications do you take? (What are they for?)

11. Do you use a device to help you walk, such as a walker, cane, crutches, etc.?

12. Are you able to stand unsupported for at least 10 minutes without losing your balance?

13. Do you have any pain or other problem that limits your ability to stand, raise your arm up, or reach?

14. How would you describe your sensation in your feet?
Fall History

1. Have you had any unexplained falls in the last 6 months?

2. How many times do you fall
   per month? ___
   per year? ___
   ever? ___

3. In which rooms in your home have you experienced a fall?

4. What obstacles, if any, have contributed to your falls?

5. What time of day have most of your falls occurred in?
   morning ___
   daytime ___
   evening ___
   nighttime ___

6. If you get up at night, do you turn the lights on?
   yes ___
   no ___

7. What kinds of things, if any, make you most fearful of falling?

8. Please feel free to elaborate on any falls you have had: how, where, and why they occurred, their consequences, or anything else you may want to tell me about your falls, balance, home safety, etc. All information will only be read by me. This paper will bear no identification of who you are.
**Screening Examination**

I. Range of Motion
   Shoulder
   Can raise arm to 90° in both flexion and abduction?
   Full ROM in shoulder?
   Pain-free shoulder ROM?

   Elbow
   Full ROM in elbow?
   Pain-free ROM in elbow?

II. Neurological Exam
   Reflexes (look for asymmetries)
   Biceps
   Patellar
   Babinski

   Coordination
   Heel-knee-shin
   Finger to nose

   Proprioception
   Great Toe

   Tone Abnormalities
   Upper extremities
   Lower extremities

III. Anthropometric Measurements

   Height
Score Sheet

Practice Trials

1. Start_ Stop_

2. Start_ Stop_

Well Lit Room

1st or 2nd

Light Level_ fc

1. Start_ Stop_

2. Start_ Stop_

3. Start_ Stop_

Adjustment Time_

Dim Lit Room

1st or 2nd

Light Level_ fc

1. Start_ Stop_

2. Start_ Stop_

3. Start_ Stop_
REFERENCES


39. Carter JH. The Effects of aging on selected visual functions: color vision, glare sensitivity, field of vision, and accommodation. In: Sekuler R, Kline D.


