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The Influence of Footwear on Functional Balance in a Population of Institutionalized Elderly Women

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THE INFLUENCE OF FOOTWEAR ON FUNCTIONAL BALANCE IN A POPULATION OF INSTITUTIONALIZED ELDERLY WOMEN

By

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THESIS

Submitted to the Department of Physical Therapy at Grand Valley State University Allendale, Michigan in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN PHYSICAL THERAPY

1998
THE INFLUENCE OF FOOTWEAR ON FUNCTIONAL BALANCE IN A POPULATION OF INSTITUTIONALIZED ELDERLY WOMEN

Abstract

The purpose of this study was to evaluate the influence of footwear on functional balance in a sample of 19 institutionalized elderly women. The Tinetti Balance and Mobility Assessment, a fall risk indicator, was used to evaluate functional balance in three footwear conditions: shoes, slippers, and barefoot. An ANOVA test (alpha < 0.05) was used to determine if there was a significant difference between the three footwear conditions. A significant difference was found between each footwear condition for the balance (p=.008) and summary scores (p=.004), but not for the gait score (p=.155). Post-hoc analysis revealed that the shoe condition provided significantly superior scores than the slipper (p=.005) and barefoot conditions (p=.043). Recommendations from this study include support for the standardization of the Tinetti Balance and Mobility Assessment for footwear, and recommendations that institutionalized elderly should wear shoes and avoid the use of slippers or barefoot to reduce fall risk.
ACKNOWLEDGEMENTS

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Appreciation must also be expressed to Michigan Christian Home for helping to make this research project a reality. We are grateful to Diane VanBennekom, who served as our liaison at Michigan Christian Home and helped to organize the implementation of this project. A special thank you to each of the residents who volunteered their time to serve as subjects in our study and made the collection of data both a fun and enjoyable experience.

We are indebted to everyone involved in this research study for their patience, understanding, and dedication to the completion of this project.
DEFINITION OF TERMS

**Adjusted heel height** – heel height (in cm.) minus sole thickness (in cm.) measured at the first metatarsal head (Briggs et al., 1989)

**Balance** – ability to maintain the center of the body’s mass over the base of support (Crutchfield and Barnes, 1993, p. 271).

**Barefoot** – wearing no shoes, slippers, or socks, but does allow for nylons to be worn

**Barthel Index** - a screening tool used to assess the functional independence of an individual. The index consists of a self-care and mobility assessment. Maximum score is 100 points (Mahoney and Barthel, 1965). (see appendix J)

**Base of Support** – The area on which an object rests and that provides support for the object (Pierson, 1994, p.11).

**Cone of Stability** – Area radiating from the base of support to the head that represents the sway from side to side and forward and backward that the person will use to attempt to maintain equilibrium with the limits of stability (Crutchfield and Barnes, 1993).

**Dynamic balance** – The ability of the body to maintain equilibrium in response to its own changing base of support during movement or as a response to external perturbations (Duncan, Weiner, Chandler, and Studenski, 1990).

**Elderly person** – An individual aged 65 and older.

**Extrinsic risk factors** – Risk factors that are external to the individual, such as activity, time of day, or environmental features.

**Fall** – A possible functional outcome of a loss in balance control with the individual coming to rest on a lower surface. (Crutchfield and Barnes, 1993).
Frailty – occurs when there is a diminished ability to carry out the practical and social activities that are important to all people and/or activities that are particularly important to the individual in question (Brown, Renwick, and Raphael, 1995).

Functional Balance- The combination of static and dynamic balance required to successfully perform a physical activity or task.

Intrinsic Risk Factors – Risk factors that are internal to the individual, such as age, gender, disease process, or medications.

Folstein Mini-Mental State Examination – Test used to quantitatively estimate the severity of cognitive impairment and to document change in cognitive status (Folstein, Folstein, and McHugh, 1975). (see appendix E)

Perturbation - An external or self-generated force which requires a compensatory postural response to maintain postural equilibrium (Smith, 1996).

Postural Control – Regulation of the body’s position in space for the direct purpose of stability and orientation (Shumway-Cook and Woollacott, 1995).

Shoes – footwear having hard rubber soles with a cloth, canvas, leather/suede, or other synthetic material upper, and fastened to the foot with either a shoe string or Velcro strap or a well fitted slip-on

Slippers – footwear having a smooth or non-skid sole with no fastener

Somatosensory System – System that receives signals from muscle, joint, and skin receptors. This input is then integrated and interpreted relative to information acquired from other sensory systems (Shumway-Cook and Woollacott, 1995).

Static Balance – The ability of the body to maintain equilibrium during quiet standing (Duncan et al., 1990).
**Tinetti Balance and Mobility Assessment** – a test to screen for functional balance and mobility skills in older adults. This assessment tool consists of two subscales with a total of 16 items that measure gait and balance activities. Maximum score is 28 points (Shumway-Cook and Woollacott, 1995). (see appendix A)

**Vestibular System** – A body system that registers the position and movements of the body in relation to gravity. The peripheral vestibular organs are located in the inner ear (Crutchfield and Barnes, 1993).
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CHAPTER 1
INTRODUCTION

Falls and the Elderly

Falls pose a serious threat to the independence and well being of many elderly individuals each year. Approximately 25%-35% of people over the age of 65 years experience one or more falls per year (Shumway-Cook, Gruber, Baldwin, Liao, 1997). This relatively high incidence of falls combined with an increased susceptibility to injury due to chronic disease and age associated changes represents a significant problem (Rubenstein et al., 1988). The outcome of falls is costly to all. Falls can lead to significant physiological, psychological, and social costs to the individual, as well as a great financial cost to society. Those who fall risk the potential for serious injury, decreased independence, decreased mobility, decreased social involvement, and even death (Rubenstein et al., 1988; Rubenstein, Robbins, Josephson, Schulman, & Osterweil, 1990).

The potential for serious injury is present with any fall. Due to age related changes in the elderly, such as decreased bone density, decreased flexibility, and slowed protective responses, even a relatively minor fall can result in severe physical consequences (Rubenstein et al., 1988). The most serious potential outcome of a fall is death. The National Safety Council has cited falls as the leading cause of accidental death in persons aged 65 and older (Cutson, 1994). Although much less serious than death, approximately one percent of the elderly who fall will incur a hip fracture, 5% will fracture some other bone, and an additional 5% will sustain a soft tissue injury (Cutson, 1994).

It is also important to recognize that those falls that are physically non-injurious can still exact a great deal of damage to the psychological and social well being of the
elderly. Many elderly who experience a fall, whether injurious or not, develop a fear of falling (Lange, 1996). They may reduce or curtail their activities and/or social involvement which could pose a threat of falling. This self-imposed reduction in activity level and social isolation leads to a vicious cycle of disuse, which increases the likelihood of experiencing another fall (Lange, 1996).

In addition to the physical and psychological costs, falls among the elderly represent a significant financial cost. In 1985 the average total cost of a fall sustained by an individual aged 65 and older was $4,226 (Englander, Hodson, and Terregrossa, 1996). This figure includes medical and rehabilitation expenses, as well as lost financial output due to injury or death. In the 1994 economy this amount increased to $7,399, which far exceeds the total cost of a fall for an individual in any other age cohort (Englander et al., 1996). Furthermore, the projected financial impact of falls in the elderly is expected to dramatically increase by the year 2020 due to the growing population of those individuals aged 65 and older (Englander et al., 1996). Also contributing to the rising cost of falls is the increased use of long-term care facilities. Approximately one-half of older adults who have been hospitalized for fall related injuries are not discharged home, but rather are placed in long term care facilities (Shumway-Cook et al., 1997).

Any elderly individual aged 65 and older has an increased susceptibility to falls when compared with younger individuals (Rubenstein et al., 1988). However, within the elderly population certain sub-groups have an increased incidence of falls when compared to others. It has been estimated that one-half of elderly nursing home residents fall each year compared to only one-third of community-dwelling elderly (Cutson, 1994; Rubenstein et al., 1990). Those elderly individuals residing in nursing homes or long term
care facilities may have an increased risk of falling due to their frailty (Rubenstein et al., 1988).

Frailty is a complex concept that has been ill-defined in the past. For the purposes of this paper, the definition by Brown et al. (1995) will be used. Frailty in an individual occurs when “...there is a diminished ability to carry out the important practical and social activities of daily living” (Brown et al., 1995). Practical activities, as defined by Brown et al., are instrumental activities of daily living, such as bathing, eating, and maneuvering around the home or community. Social activities include a consistent interaction with family, friends, and acquaintances, and the giving and receiving of support.

It is important to recognize that the factors influencing frailty can be unique to each individual. These factors have been categorized as personal or environmental in nature. Personal factors include cognitive abilities, physical function, psychological status, and spiritual health (Brown et al., 1995). Environmental factors include such things as financial control, availability of support systems, living situations, accessibility to a variety of environments, and control over daily activities and routines (Brown et al., 1995). Frailty is not dependent upon the age of the individual, nor is it a fixed state of being; rather, frailty is a dynamic state influenced by multiple interacting factors.

Those individuals that are considered to be frail may have an increased susceptibility to falling (Tinetti and Speechley, 1989). Since the potential for falling is greater in this population, it is important to implement strategies that will reduce or alleviate the risk for falling. The key to fall prevention is an understanding of the underlying causes. In the past, the medical model, which focuses on the concept that one
entity or disease process is responsible for an outcome, was used to determine the 
causative factor of a fall (Cutson, 1994). Recently this model has been determined to be 
inappropriate as falls are considered to be multifactorial in nature. Hence, a fall may result 
when a variety of factors interfere with the body’s ability to maintain balance. These 
factors have been divided into two categories: intrinsic factors (those that are internal to 
the individual) and extrinsic factors (those associated with environmental features.) Some 
intrinsic factors that have been identified as probable causative factors include 
polypharmacy, certain disease processes, balance and gait disorders, and age (Tinetti and 
Speechley, 1989; Venglarik and Adams, 1985). Extrinsic factors include such things as 
unstable furniture, shiny floors, throw rugs, dim lighting, and poor footwear (Fleming and 
Pendergast, 1993; Tinetti and Speechley, 1989). Extrinsic factors are notably the most 
simple risk factors to modify, but yet still account for more than one-third of falls in the 
elderly (Rubenstein et al., 1988).

Problem Statement

Research which investigates and controls for extrinsic factors contributing to falls 
in the elderly is limited. One problem that exists in the literature is a lack of experimental 
studies controlling for footwear that demonstrate the relationship between the type of 
footwear worn and the risk of falls in the elderly. Numerous recommendations have been 
made regarding the type of footwear that should be worn to decrease risk of falls, but 
there is little experimental evidence that would either support or contradict these 
recommendations. One study looked at the role of footwear on balance (Briggs et al., 
1989). However, the researchers chose to only assess the relationship of footwear to
static balance. Assessment of static balance has limited application to falls in that many falls occur while walking, which requires dynamic balance (Fleming and Pendergast, 1993). The study by Briggs et al. (1989) was also conducted with community-dwelling elderly, which leaves many questions as to its relevance to institutionalized and frail elderly. A second study, by Robbins, Gouw, and McClaran (1992), looked at the relationship between footwear and dynamic balance in 25 elderly men. These researchers found that there was a significantly lower frequency of balance failures when wearing shoes as compared to when barefoot. The elderly sample in the study by Robbins et al., however, consisted only of community-dwelling elderly. Lord and Bashford (1996) conducted one of the most recent studies examining the effects of footwear on balance. These researchers measured the static and dynamic balance of 30 elderly women in four different footwear conditions. The researchers found that subjects performed tests of static balance best while barefoot, and that low-heeled shoes provided the best outcome in measurements of dynamic balance. Although this study examined balance in a mixed population of community-dwelling and institutionalized elderly, no assessment was made in regard to functional balance. Measurements of functional balance are important as they take into consideration the combination of static and dynamic balance required to perform a task or activity.

**Foundation for Further Studies**

The three studies mentioned above provide a sound support for the need to continue to examine the relationship between type of footwear and risk of falls in the institutionalized elderly. The fact that two of the studies used only noninstitutionalized
elderly subjects leaves a gap in the literature on falls in regard to the role of footwear in falls experienced by the institutionalized and frail elderly. It is important to study this cohort as they have been shown to be at a greater risk of falling than the community-dwelling elderly (Cutson, 1994; Rubenstein et al., 1990). Furthermore, it is believed that institutionalized and frail elderly have an increased susceptibility to minor environmental hazards, such as footwear, as opposed to their less frail counterparts (Tinetti and Speechley, 1989). Finally, if footwear is shown to have a significant impact on an elderly person’s ability to maintain balance and therefore decrease the likelihood of experiencing a fall, sound rationale will exist to support recommendations for footwear alterations. If there is a significant relationship between footwear and functional balance, the indirect outcome of this study will provide for a practical, simple, and inexpensive strategy to further decrease the potential risk for falls in this population.

**Purpose of the Study**

The purpose of this study was to examine the relationship between three types of footwear conditions and functional balance in a population of institutionalized and frail elderly. More specifically, the types of footwear that were examined included shoes, slippers, and barefoot conditions. The assessment tool that was used to measure functional balance was the Tinetti Balance and Mobility Assessment (see appendix A). A secondary purpose of this study was to determine whether or not the Tinetti Balance and Mobility Assessment should be standardized for different footwear conditions.
Hypothesis

In a population of institutionalized and frail elderly, functional balance, as measured by the Tinetti Balance and Mobility Assessment, will be significantly better in the shoes condition as compared to the slipper or barefoot conditions.
CHAPTER 2
REVIEW OF THE LITERATURE

Balance and Postural Control

One of the most important components in preventing a fall is the maintenance of balance. Balance is an essential part of movement and skill, and is defined as the ability to maintain the center of mass over the base of support (Crutchfield and Barnes, 1993). Two conceptual theories used to describe postural and balance control are the hierarchical and the systems theories. The theoretical framework for this study was based on the systems approach. As opposed to focusing on the evolution of reflexes during development, the systems theory proposes that "postural actions emerge from an interaction of the individual, the task with its inherent postural demands, and the environmental constraints on postural actions" (Shumway-Cook and Woollacott, 1995, p.120). According to this theory, the musculoskeletal and neural systems interact to provide both the sensory information needed to assess position or motion and the ability to generate the necessary forces for controlling body position (Shumway-Cook and Woollacott, 1995).

Motor strategies are one of the important components in the maintenance of postural control. The primary goal of postural control is to provide stability and orientation for the body. Because this study focuses on postural control as it relates to dynamic balance, it is important to understand the motor strategies used during a perturbation. The activation of muscle synergies is crucial to maintaining balance during a perturbation (Shumway-Cook and Woollacott, 1995). Shumway-Cook and Woollacott (1995) defined a synergy as "...the functional coupling of groups of muscles such that they are constrained to act together as a unit; this simplifies the control demands on the
central nervous system" (p. 127). The ankle strategy, one of the postural movement strategies, is activated in response to small perturbations on a firm surface. A second strategy, the hip strategy, is used primarily during large, fast perturbations, or during perturbations on a smaller support surface. The final strategy used during perturbations is the stepping strategy. During a perturbation large enough to displace the center of mass outside the base of support, a person will hop or step to regain their balance (Shumway-Cook and Woollacott, 1995).

Along with the motor strategies used to maintain postural control, sensory strategies play a key role. The three systems involved in providing this information are the visual, somatosensory, and vestibular systems. Different combinations of these three systems may be used to maintain postural control based on the environmental demands of the situation (Woollacott and Shumway-Cook, 1990).

The visual system gives a person information regarding the position and motion of the head with respect to surrounding objects. This system has trouble distinguishing between object motion and self-motion. Therefore, while the visual system may give necessary and proper information, the brain may misinterpret this information. Children who are developing motor control tend to rely more heavily on vision than do normal, neurologically intact adults (Shumway-Cook and Woollacott, 1995). While vision is a very important factor in maintaining balance, if it is missing or diminished, other sensory systems will compensate. Sensory compensation can be illustrated by a blind person's ability to maintain balance even though there is no visual input.

The vestibular system is involved in sensing the position and movement of the head with respect to gravity. The semicircular canals are responsible for detecting angular
accelerations and are very sensitive to fast movements, such as those during a trip or stumble. The otoliths, a component of the vestibular system, monitor linear position and acceleration and are very sensitive to small movements such as postural sway (Shumway-Cook and Woollacott, 1995). "The vestibular system acts as the body’s internal reference system for determining the appropriateness of other sensory information. It is involved in the resolution of intersensory conflicts when information from other systems is misinterpreted or the correct information is not conveyed” (Crutchfield and Barnes, 1993, p. 272). It is the ability to resolve these sensory conflicts that is critical to preventing loss of balance or falling.

The somatosensory system informs a person of the position and motion of the body in space with respect to supporting surfaces. Joint, muscle, cutaneous, and pressure receptors are responsible for gathering this information. These receptors also tell a person the texture of the supporting surface (Shumway-Cook and Woollacott, 1995). Dietz, Trippel, and Horstmann (1991) found that during perturbed stance, muscle response latency times were much faster for somatosensory inputs than for vestibular inputs. The study concluded that the contribution of the vestibular system was smaller than that of the somatosensory system in maintaining balance during support surface perturbations. Therefore, the somatosensory system played a larger role in the recovery of postural control. This finding supports the consensus in the literature that neurologically intact adults tend to rely heavily on somatosensory inputs for the maintenance of balance (Shumway-Cook and Woollacott, 1995).
Aging and Postural Control

Aging has a deteriorating effect on multiple aspects of postural control. Extensive research has been performed on the age-related changes in the subsystems involved in efficient balance control. Subsystems that have shown decline in the elderly include the sensory, motor response, higher level nervous system (adaptation), and musculoskeletal system (Woollacott, 1990).

There is documented decline in the visual, vestibular, and somatosensory systems in the elderly. Two studies found that both cutaneous vibratory sensation and joint sensation were significantly decreased in older adults (Skinner, Barrack, and Cook, 1984; Whanger and Wang, 1974). Rosenhall (1973) found a 40% reduction in sensory cells within the vestibular system in individuals beyond 70 years of age. Vision has also been found to decline in the elderly. A study by Sekuler and Hutman (1980) found significant deterioration in the sensitivity of older adults to low frequency spatial information. Spatial information is important, because it is used heavily in locomotion and postural stabilization.

The importance of peripheral vision and somatosensation for balance control in the elderly was illustrated in a study by Manchester, Woollacott, Zederbauer-Hylton, and Marin (1989). The purpose of their study "...was to determine whether age related changes exist in the relative contributions of visual and somatosensory inputs to balance control" (Manchester et al., 1989, p.119). When compared to younger adults, older adults receiving only foveal and vestibular input were found to be less stable under conditions in which peripheral vision was occluded and ankle somatosensation limited.
The three systems, visual, somatosensory, and vestibular, give important information to the body to maintain balance. Woollacott, Shumway-Cook, and Nashner (1986) found that when the elderly were confronted with functionally inappropriate visual and/or somatosensory input, half of the older subjects lost their balance. However, when only one inappropriate input was given, the majority of elderly subjects were able to maintain their balance. The researchers hypothesized that this finding supports the systems model due to the body's ability to shift to an alternate sensory system as long as two out of the three systems are available in the elderly. Nashner (1976) believed that the redundant sensory inputs were necessary to maintain stability when one or more inputs were lost. If one sensory system is diminished or lost, dependency is then shifted to the remaining sensory inputs.

Sensory impairment in the elderly can be seen in gait deviations found in the normal healthy elderly. Healthy, elderly men, age 65 years or older, were shown to have shorter and broader stride dimensions, slower cadence, and longer swing to stance time ratios (Murray, Kory, Ross, and Clarkston, 1969). Rather than resembling a pathological gait, the gait of the elderly men appeared to be guarded or restrained. Murray et al. (1969) believed that this restrained gait was due to attempts to maximize stability and security while walking.

Age related changes relating to motor response have been found in numerous studies. Woollacott et al. (1986) conducted a study involving 12 older adults and 14 young adults. Using a moveable platform and electromyographic analysis, they found the following in the elderly subjects: a significant increase in absolute latency of distal muscle responses to sway within a muscle synergy, temporal reversals of proximal and distal
muscle response onset, larger incidence of short latency spinal monosynaptic reflexes, and breakdown in the correlation of the amplitude of responses within the muscle synergy.

In a study comparing young adults to older adults, Manchester et al. (1989) used platform translations to evaluate differences in muscle responses to postural perturbations. They found that older adults co-activated antagonist muscles with the agonist muscle significantly more than did young adults when responding to platform translations. The researchers also found that younger subjects tended to activate fewer muscles to accommodate for perturbations than the older subjects.

The decline in the musculoskeletal system of the elderly has been well documented. Normal age associated changes include forward head, thoracic kyphosis, increased stiffness in connective tissue in aging muscle, and stretch weakness in muscle (Kauffman, 1990). There has also been shown to be a loss of type II fast twitch fibers, a decrease in the speed of contraction, and a decrease in muscular strength (Kauffman, 1990). The explanation of the increased use of the hip strategy found in the elderly may also include a musculoskeletal component. Older subjects may not be able to generate the torque necessary at the ankle to produce the proper synergy (Manchester et al., 1989). All of these changes within the musculoskeletal system may alter the older person’s ability to recover from a loss of balance or perturbation (Kauffmann, 1990).

Fall Risk Factors

It is well documented in the literature that the elderly experience a decline in the systems involved in postural control. With this decline comes an increase in the risk of falling. A fall is a possible functional outcome of a loss in balance control with the
individual coming to rest on a lower surface (Crutchfield and Barnes, 1993). "Falls arise from the complex interplay between an individual, his/her physical state, and the built or natural environment" (Fleming and Pendergast, 1993, p.627). It is important when addressing the topic of falls to discuss the contributing factors. Intrinsic and extrinsic risk factors have been a central focus of study in a majority of literature pertaining to falls for the last several decades.

There are a multitude of intrinsic factors, those factors that are internal to the individual, that have been identified as potential risk factors for falls. Some intrinsic factors are fixed or not modifiable, such as age and gender. It is well established in the literature that with increasing age comes a proportionate increase in the risk of falling (Venglarik and Adams, 1985). In a study by Venglarik and Adams, 221 residents of a skilled nursing facility experienced 933 falls over a three-year period. These researchers found that falls increased with age and showed a slight decline only after the age of 90. This same study also showed that 88.7% of the recorded falls were experienced by women; however, no reference was made to the ratio of men to women participating in the study. Women are commonly cited in the literature as experiencing a greater number of falls than men. This, however, may be due in part to the disproportionate population of women compared to men in long term care facilities, a common site for fall related research (Myers et al., 1989; Robbins et al., 1989; Rubenstein et al., 1990). Other intrinsic risk factors described in the literature include: decreased visual acuity and dark adaptation, vestibular dysfunction, dementia, postural hypotension, balance and gait abnormalities, peripheral neuropathy, neurologic conditions, and medications (Tinetti and Speechley, 1989).
Extrinsic risk factors are those factors that are associated with the environment. There is a varied opinion as to the impact that environmental factors have on the incidence of falls. Fleming and Pendergast (1993) initiated a retrospective analysis of 394 individuals residing in an adult care facility over a three-year period. During the three years, 294 falls involving 95 residents were reported. In a review of the fall incident reports, Fleming and Pendergast were able to assess the relative importance of three categories of fall risk factors for their sample population. The categories included environmental features, the physical condition of the resident, and physical activity. They discovered that over 50% of the 294 falls were related to environmental factors, compared to 24.3% relating to the resident's physical condition, and 7.9% relating to physical activity at the time of the fall. The environmental features directly implicated as precipitating factors included furniture, walkers, floor finish, stairs, footwear, vehicles, bath/toilet, and wheelchairs. These factors were reported from most common precipitating factor to least common.

Although extrinsic factors contribute to many falls, it is important to remember that falls are considered to be multifactorial. Therefore, it is difficult and improbable to cite any one factor or type of factor as contributing more than another to a fall. In a number of studies and papers by leading experts in fall research, there is a move away from the idea that extrinsic factors are the primary cause of falls experienced by the elderly. In a prospective study by Lipsitz, Jonsson, Kelley, and Koestner (1991), only 10% of the index falls in 70 long-term care residents with recurrent falls were associated with environmental hazards. The researchers conclude that their “...experience suggests that most multiple fallers, with an environmentally related episode, fall because of
underlying pathologic conditions that impair their ability to compensate for the hazardous situation" (Lipsitz et al., 1991, p. M121). Even Fleming and Pendergast (1993), who found retrospectively that the environment was related to more than 50% of the reported falls, concluded that “...the cause of the fall may be attributed to the resident’s inability to interact with the environment due to his/her physical limitations” (p. 629). Hindmarsh and Estes (1989) also proposed the idea of “threshold” in regard to the interaction between intrinsic and environmental/extrinsic factors. The threshold model suggests that a number of risk factors in combination predispose a person to falling. However, a fall will only result when an accumulation of predisposing risk factors exceeds the individual’s “fall threshold” or ability to compensate. Regardless of whether or not environmental hazards are the primary or secondary cause of a fall, they do play a significant role in falls within the elderly.

The environmental hazards that have been identified in the literature are numerous but by no means exhaustive. Different populations of elderly individuals encounter different environmental hazards, which significantly complicates the study of the impact of extrinsic factors on falls. For example, community-dwelling individuals encounter seasonal hazards and kitchen hazards more frequently than individuals living in a long-term care facility. This difference is due primarily to accessibility and functional capabilities of the individual. Tinetti (1987) reported that some researchers believe that those elderly living in long-term care facilities have a decreased chance of falling due to extrinsic risk factors compared to their community-dwelling counterpart. This difference is thought to be true because many facilities are designed or adapted to eliminate environmental hazards that can precipitate falls. However, Fleming and Pendergast (1993) found that even in the
relatively "safe" environment of the adult care facility, roughly 27% of the total number of residents still fell. The researchers proposed that this finding was because "...aspects of the environment that appear to be safe for fully functioning individuals present hazards to an ambulatory, but frailer, older population requiring custodial care" (Fleming and Pendergast, 1993, p. 629). Tinetti and Speechley (1989) also acknowledged that with increasing frailty comes an increased susceptibility to even minor hazards, such as long pant legs or poorly fitted shoes.

Specific extrinsic factors that have been identified as risk factors for nursing home residents include such things as furniture, assistive devices, floor finish, stairs, footwear, vehicles, bath/toilet, and wheelchairs (Fleming and Pendergast, 1993). This list is by no means complete. Fleming and Pendergast also found that the activity most commonly associated with falls was walking. Forty-two percent of the falls directly linked to physical activity were attributed specifically to the activity of walking (Fleming and Pendergast, 1993). In a case study by Rubenstein et al. (1988), a 95 year old board and care resident fell while bending to pick an object up off the floor. The patient stated that she experienced no dizziness, but just "lost her balance." No obvious environmental hazards were present, but the researchers did mention that the woman was wearing loose fitting slippers and was not using her cane. Recommendations were made to modify her footwear and increase the use of her assistive device.

The question that seems appropriate to ask is: "why focus on extrinsic factors when their relative importance to falls is somewhat inconclusive in the literature?" It is important to identify extrinsic factors related to falls for the reason that these factors are usually the most easily modified, and the elimination or reduction of these hazards may
prevent many elderly from exceeding their "fall threshold." Tideiksaar designed an intervention addressing extrinsic risk factors for 25 ambulatory elderly individuals who experienced three or more falls that were precipitated by environmental factors within the previous three months. Twelve months following elimination of these extrinsic hazards in their homes, 56% of the participants experienced no further falls, 36% continued to fall but less frequently, and only 8% fell as frequently as before the intervention (Tideiksaar, 1990). This study provides evidence that modification of extrinsic risk factors can aid in the prevention of future falls.

Footwear and Falls

Numerous studies mention footwear as an extrinsic risk factor or make recommendations as to what footwear should be worn to prevent falls. However, there are relatively few studies that are designed to control for the footwear variable (Brady et al., 1993; Fleming and Pendergast, 1993; Lange, 1996; Lipsitz et al., 1991; Rubenstein et al, 1988; Sehested and Severin-Nielsen, 1977; Tinetti and Speechley, 1989). Briggs et al. (1989) designed a study to look at the difference between standing balance in the eyes open and eyes closed conditions, as well as shoes-on and shoes-off conditions in noninstitutionalized elderly women. Seventy-one noninstitutionalized elderly women between the ages of 60 and 86 years participated in the study. These women were independent in activities of daily living and were without Parkinson’s disease, cerebral vascular accident, multiple sclerosis, or serious musculoskeletal problems. Nineteen of the 71 participants reported having fallen at least once within the last year. Balance was measured via the Sharpened Romberg test and the One-legged stance test, both of which
measure static standing balance. Subjects were asked to perform each test four times for the four different test conditions: eyes open, eyes closed, shoes on, and shoes off. There was no control for the type of shoe worn by the participant; however, adjusted heel height was measured. The range for adjusted heel height, which is the heel height minus sole thickness measured at the first metatarsal head, was 0.0cm to 5.9 cm. The results of the study showed no significant difference in mean balance time for either balance test between subjects who had fallen versus those who had not fallen, nor any difference between shoes on and shoes off conditions. The researchers concluded that footwear had no effect on balance performance in their population of noninstitutionalized elderly women.

Robbins et al. (1992) also looked at the relationship between footwear and stability. More specifically, they investigated the relationship between midsole thickness and stability in a sample of 25 healthy men age 60 and older. The men were asked to walk on a 9.0-meter long balance beam that was 7.8 cm wide and rested 3.9cm off of the floor in seven different footwear conditions. Six of the seven conditions involved identical shoes with varying midsole thickness, and the seventh condition involved subjects walking barefoot. The measurement taken was labeled as balance failure frequency, which was the number of falls per 100 meters. The researchers chose the beam-testing method primarily because it allowed for the participants to demonstrate dynamic balance. Robbins et al. stated that the selection of a dynamic balance task was chosen in response to a concern with previous research that used measurements of static balance. The concern was that measurements of static balance provided an inadequate link to falls. This concern is based on the premise that falls in the elderly population primarily occur during
locomotion, which is an activity requiring dynamic balance. The results of the study showed a significantly lower frequency of balance failures when wearing shoes as compared to when barefoot (P< 0.0001). In fact, the barefoot condition was associated with a balance failure frequency of 171% greater than the shoe condition affording the best stability, and 19% greater than the shoe condition with the poorest performance. They also found that the thicker midsoles caused a greater frequency of balance failures than the thinner midsoles. Based on their findings, Robbins et al. recommended that “... it might be sensible for physicians managing elderly patients with a history of falls to suggest that he or she avoid barefoot locomotion completely, and wear footwear with hard soles at all times when upright” (p. 1093). Robbins et al. also concluded that even soft-soled slippers should be avoided.

Lord and Bashford (1996) initiated a study in response to concerns about the artificial testing environment (use of the balance beam) employed by Robbins et al. (1992). Lord and Bashford measured the static and dynamic balance of 30 elderly women in four different footwear conditions. Twenty-five of the subjects resided in a hostel that provided intermediate care (meals, house cleaning, etc.), and the remaining five subjects lived independently within the community. The four footwear conditions consisted of barefoot, standard low-heeled shoes (heel height of 1.6 cm.), standard high-heeled shoes (heel height of 6 cm.), and the subject’s own shoes. The shoes worn in the last test condition varied greatly. Shoe types included slippers, running shoes, and low and high-heeled court shoes. Three tests were performed for each footwear condition. Body sway, which is the displacement of the body at the level of the waist, was assessed to measure static balance during quiet stance. Body sway was evaluated using a swaymeter. A
swaymeter is a simple device that consists of a rod, pen, and a piece of graph paper. The pen is attached to the tip of the rod, and the rod extends behind the subject at the level of the waist. Any movement of the body is depicted by the subsequent movement of the pen on the graph paper. In this study, body sway was recorded as the number of millimeter squares on the graph paper traversed by the pen in 30 seconds. The second test, maximal balance range, was used to assess dynamic balance. The maximum distance a participant could move in the forward and backward direction without moving his feet or losing his balance was defined as the maximum balance range. Again, the number of millimeter squares traversed by the pen in a forward and backward direction was recorded as the maximum balance range. The final test, referred to as the coordinated stability task, measured the subject's ability to adjust balance in a steady and coordinated manner while at or near the limits of stability. The subjects were asked to keep the pen of the swaymeter in a defined track without moving their feet. Any excursion of the pen outside the path was scored as an error. The sum of errors was recorded as the subject's score for coordinated stability.

The results of the study by Lord and Bashford (1996) showed that subjects performed best in the barefoot condition during the sway and coordinated stability tests. This finding directly contradicts the results found in the study by Robbins et al. (1992). Robbins et al. found that the barefoot condition hindered balance in elderly individuals. Lord and Bashford (1996) also found that during the maximum balance range test, subjects performed best in the low-heeled shoe and worst in their own and high-heeled shoes. The contradictory findings of this study with the Robbins et al. (1992) study provide support for the need to continue to investigate the relationship between footwear
and balance in the elderly. Also, there are a limited number of published studies that investigate the relationship between footwear and balance, which provides further support for research in this area.

**Measuring Risk of Falls**

Finding a tool that predicts the likelihood that someone will fall is important in identifying those elderly at risk for suffering a fall. The trend for assessing fall risk is currently shifting away from the medical assessment and toward the use of performance-based assessment tools that are easy to administer and efficient. Performance oriented assessment tools focus on the measurement and classification of functional activities and an individual’s ability to successfully engage in the activity. A task is presented and the patient is asked to perform. The patient is given assistance when needed and then scored, according to the test criteria being used (Guccione, 1994).

Previously, many clinicians relied on the disease-oriented approach to predict function in the elderly. The disease approach attempts to gather data from a patient’s history, physical examination, and lab results to predict the underlying pathophysiology and the expected functional outcome. Tinetti (1986) found many limitations with this approach. She believed it was inadequate, especially in the elderly, because of the multifactorial nature of falls and the inconsistent relationship between anatomical and biochemical abnormalities and function. Tinetti (1986) also thought it was possible to “accumulate a great deal of data yet have no understanding of a person’s function or mobility” (p. 119). She stated that the primary problem with the disease-oriented approach was that it ignored the fact that falling is a clinical entity in its own right. Tinetti
(1986) stated that, "concentrating on diagnosing the disease for which often little can be
done can lead to ignoring or underplaying symptoms or disabilities for which often much
can be done." (p.120).

Other tests being used to predict falls in the elderly concentrate on detailed gait
analysis, measurement of postural sway, and neuromuscular findings. These tests are often
expensive and not very practical for older persons with mobility problems (Tinetti, 1986).
Gait analysis, performed in an artificial setting, does not measure the effect of the
environment, which has been shown to be an important factor in mobility and falling
(Tinetti, 1986). Postural sway tests measure static balance. Static balance is important;
however, it is not the type of balance needed for many activities of daily living. Dynamic
balance is much more important to many functional activities.

Many researchers today are using performance oriented mobility assessments in
their research on falls. These tests can be used initially to describe a patient's current level
of function and then as an indicator of the success of an intervention (Guccione, 1994).
Assessments commonly used in research and the clinic include the Berg Balance Scale,
Dynamic Gait Index, the Gait Assessment Rating Scale (GARS), and the Tinetti Balance
and Mobility Assessment.

The Berg Balance Scale was developed to measure the functional balance of
elderly individuals (Berg, Wood-Dauphinee, Williams, and Gayton, 1989). This 14 item
assessment tool requires an individual to perform a variety of activities in sitting, standing,
and single-limb support. Each test is scored on a five point scale (0-4) according to the
quality of performance and the time taken to complete the task. The strength of this test is
its greater sensitivity to predicting falls than the Tinetti Balance and Mobility Assessment.
However, unlike the Tinetti Balance and Mobility Assessment, the Berg Balance Scale does not include a gait assessment, which is important when assessing functional balance. In a study by Fleming and Pendergast (1993), the frequency and cause of falls in a group of elderly individuals was studied. Of the 294 falls surveyed, 7.9% of the total falls were precipitated by a physical activity that contributed to the fall. In 42% of these falls, walking was the physical activity that precipitated the fall. When examining the effect of footwear on functional balance, gait may be the component of functional balance that is most affected by different footwear conditions.

Another performance oriented assessment tool that is currently being used is the Dynamic Gait Index. The Dynamic Gait Index evaluates a patient’s ability to modify gait in response to changing task demands (Shumway-Cook and Woollacott, 1995). The patient is graded on eight items scored from 0-3. The demands placed on the subject include changes in gait speed, rotating head during gait, and stepping over and around obstacles. However, while the Dynamic Gait Index does assess gait, it’s validity and reliability are not well documented in the literature.

The GARS is a test used to evaluate gait patterns. It includes observation of 4 categories of gait abnormalities, and trials are often videotaped in order to best perform the detailed analysis. The GARS has been used to detect gait problems in the elderly and has been shown to be sensitive to indicating changes in gait function (Shumway-Cook and Woollacott, 1995). While the GARS is a quantitative, detailed documentation of gait, it is not as performance oriented as the Tinetti Balance and Mobility Assessment. The GARS is time consuming to perform and requires a solid understanding of and experience in gait observation. It is also important to remember that the GARS will pick up small
abnormalities in gait that may not necessarily affect functional balance, which is the focus of this study.

The Tinetti Balance and Mobility Assessment was developed based on the need for an assessment tool which "...required no equipment and little experience to master, was reliable yet sensitive to significant changes, and reflected postural changes and gait maneuvers used during activities of daily living" (Tinetti, 1986, p. 125). The assessment is divided into a balance and a gait sub-test. Tinetti (1986) stated that, "...the balance portion stresses stability, while the gait portion attempts to detect obvious problems in gait, observe function, and identify potential measurements for improvements" (p. 123). Tinetti believed that the gait portion was important because it allowed the tester to observe functional gait rather than meticulously analyzing gait to look for small abnormalities. Again, there are some individuals with abnormalities in their gait, who are able to function both safely and effectively. The Tinetti Balance and Mobility Assessment acknowledges this phenomenon and does not factor small gait abnormalities into the grading criteria. Emphasis is instead placed on the parts of gait and balance necessary for safe and normal function (arising, immediate standing, turning). Although this study does not seek a detailed examination of gait, gait is still important to assess as it has been implicated as a precipitating cause of some falls (Fleming and Pendergast, 1993). The effect of different footwear conditions on functional balance also may be more clear if a gait portion is included in the assessment.

The Tinetti Balance and Mobility Assessment was also developed as an assessment tool useful for predicting falls in an elderly population. A study done by Tinetti, Williams, and Mayewski (1986) sought to identify the combinations of characteristics that
predisposed some elderly persons to falling. Subjects were residents of an intermediate care facility, and were independent or required minimal assistance in activities of daily living. Subjects completed a questionnaire that looked at self perceived attitudes toward health and mobility, a mental status exam, the Philadelphia Morale Scale, and an exam which looked at cardiac abnormalities, orthostatic hypotension, vision, hearing, neuromuscular, and musculoskeletal abnormalities. The outcome of interest in this study was the recurrent falls experienced (two or more falls) during the first three months of intermediate care facility residence. Tinetti et al. (1986) found that 76% of recurrent fallers had a summary score of less than 19 on the Tinetti Balance and Mobility Assessment. This finding showed that among the particular variables examined, the balance and gait performance oriented assessment was the single best predictor of recurrent falling.

A study by Robbins et al. (1989) used a population of institutionalized and non-institutionalized elderly to rank fall risk factors. The sample consisted of 149 institutionalized elderly and 68 non-institutionalized elderly. A comprehensive physical assessment, including the Tinetti Balance and Mobility Assessment, was performed on all subjects by a nurse practitioner. Results of the study showed that in fallers in both populations, a low Tinetti balance score was a significant and independent predictor of falls.

The Tinetti Balance and Mobility Assessment is a valid performance oriented assessment of functional balance in the elderly. It has also been shown to be predictive of falling in the institutionalized elderly. Since performance of balance tasks is associated with fall risk in the elderly, the use of the Tinetti Balance and Mobility Assessment to
measure functional balance in different footwear conditions may provide valuable information on the contribution of this extrinsic factor to fall risk.
CHAPTER 3
METHODOLOGY

Study Design

The design of this study was a one-way repeated measures design that measured the effects of three different footwear conditions on functional balance in a group of institutionalized elderly. The Tinetti Balance and Mobility Assessment was used to measure functional balance. The one-way repeated measures design exposes one group of subjects to several levels of the independent variable (Portney and Watkins, 1993). In this study, the independent variable was the type of footwear that the subjects were wearing. The three footwear conditions that were examined included shoe, slipper, and barefoot. The footwear conditions were chosen because they represent the most common type of footwear worn by the elderly. A telephone survey of 652 community-dwelling elderly found that sturdy shoes, barefoot, and household slippers were the most common types of footwear worn at the time of the call (Dunne, Bergman, Rogers, Inglin, & Rivara, 1993). For the purposes of this study, shoes were defined as having hard rubber-soles with a cloth, canvas, leather/suede, or other synthetic material upper, and are fastened to the foot with either a shoe string or Velcro strap or are a well-fitted slip-on. Slippers were defined as having a smooth or non-skid sole with no fastener. The operational definition for barefoot excluded the wearing of shoes, slippers, or socks, but did allow for nylons to be worn.

The dependent variable for this study was the summary score of the Tinetti Balance and Mobility Assessment. A summary score, which is the sum total of the balance and gait sub-scales, was obtained for each of the three footwear conditions. The
hypothesis was that the summary score would be significantly better in the shoe condition as compared to the slipper or barefoot conditions.

The advantages of this type of design were two-fold. First, the subjects served as their own controls, as they were exposed to all levels of the independent variable (Portney and Watkins, 1993). This type of design eliminated the need for a control group, which reduced the number of subjects needed for the study. This design also allowed for more variability in the sample as there was no need to carefully match the experimental subject group characteristics with those characteristics of the control group.

The one-way repeated measures design did have an inherent disadvantage, however. Since each subject performed the Tinetti Balance and Mobility Assessment in three different footwear conditions, there was the possibility of a learning effect occurring (Portney and Watkins, 1993). The learning effect was addressed by randomizing the order in which the footwear was worn.

**Study Site**

The study was conducted at Michigan Christian Home (MCH) in Grand Rapids, MI. Prior to the study, the facility received a preliminary letter of introduction (see Appendix B). Included with the letter was a description of the study, the informed consent form, the Tinetti Balance and Mobility Assessment, the Folstein Mini-mental state examination (MMSE), the pre-assessment questionnaire, the medical records confidentiality statement, and the Barthel Index (see Appendices C, D, A, E, F, G, and J respectively).
After agreeing to participate in the study, the administrator of MCH provided descriptive characteristics of the facility. MCH houses 107 residents in three levels of care. The Home for the Aged (HFA), the Assisted Living Center (ALC), and the Health Care Center (HCC) are the three categories of care. At the time of this study, HFA consisted of 60 residents who were independent with self-care activities but were provided with meals and housecleaning services. Eighteen individuals resided in the ALC. They were provided with twenty-four hour nursing supervision and assistance with self-care activities. The 29 residents in the HCC required twenty-four hour nursing care. There were 16 males and 91 females at MCH with ages ranging from 54 to 106 years of age. The mean resident age was 90 years.

Michigan Christian Home offers many activities for the residents including Bible studies, missionary meetings, exercise classes, singing groups and special events such as traveling choral groups. A group of residents also ran a store in which common household items were sold.

The interior environment of MCH, especially floor surface and lighting, is also an important characteristic. It is important to describe the environment in which the resident's live because these extrinsic factors can potentially influence functional balance. Resident's rooms, hallways, and bathrooms have cream-colored walls and overhead fluorescent lighting. The HCC has tiled floors, while the HFA and ALC have low pile carpeted floors. The carpeting in the HFA is of a solid color; whereas, the floor covering in the ALC is of a subtle paisley design.

Private pay, Medicaid, and Social Security are the primary means of payment at Michigan Christian Home. At the time of this study, 95% of the HFA residents were
private pay and five percent relied on Social Security Income. The ALC residents were 100% private pay, while the HCC was 60% Medicaid and 40% private pay.

Actual data collection was conducted in a lightly trafficked hallway that was well lit with overhead fluorescent lights, as well as natural light from a large window at the end of the hallway. Twenty feet of open floor space was available, which allowed for plenty of room for both the researchers and subjects to maneuver. The floor was covered with low pile carpet of a solid color. The testing took place at periods between meals in the morning and afternoon when there was little commotion or distraction in the hallways.

Subjects

This study’s target population was elderly nursing home residents, age 65 or older. Twenty-one residents volunteered for the study, but only 19 were included. A convenience sampling method was used to select the volunteers. This sampling method was chosen because the time and resources required to implement a random sampling method of the nursing home was beyond the scope of this study.

A preliminary informational meeting was held for the residents of the facility. The information presented included a brief description of the study, inclusion/exclusion criteria, materials needed (footwear types), safety measures to be implemented, and the role of the participant. All interested residents were then invited to participate in the screening process. This screening exam was held at a later date. The screening process included signing of the informed consent form (see Appendix D), completion of the pre-assessment questionnaire (see Appendix F), Barthel Index (see Appendix J), and MMSE (see Appendix E), and demonstration of the ability to independently walk 40 feet with or
without an assistive device. A detailed sequence of the screening process is provided in
the section labeled "Procedure."

Subjects were included on the basis of the following criteria: (a) 65 years of age
or older, (b) resident of a nursing home, (c) demonstrate the ability to follow a three-step
command as evidenced by the subject’s ability to score a minimum of three points on part
three of the language subset of the MMSE, and (d) ability to independently walk a
minimum of 40 feet with or without the use of an assistive device or brace. The exclusion
criteria were as follows: (a) amputation of the leg or foot, (b) physician’s diagnosis of
Parkinson’s disease, (c) history of cerebral vascular accident or traumatic brain injury with
residual deficits as diagnosed by a physician, (d) physician’s diagnosis of a vestibular
condition, such as Meniere’s disease or Benign Paroxysmal Positional Vertigo with
continuing deficits, (e) physician’s diagnosis of multiple sclerosis or other neurologic
disorder, (f) legal blindness as diagnosed by a physician, (g) crippling arthritis or painful
foot conditions that restricts the individual’s ability to walk, and (h) unstable heart
conditions (i.e. unstable angina, congestive heart failure, or preventricular contractions) as
documented by a physician. Individuals diagnosed with any of the above were excluded
because the researchers believed that the physical conditions could cause inconsistencies in
performance between the three trials. These inconsistencies might then overshadow the
possible influence of footwear. These criteria for inclusion into and exclusion from this
study were obtained through the pre-assessment questionnaire. The researchers verified
the subjects’ answers through review of their medical records.
Instruments and Equipment

Three standardized instruments were used in this study. The first standardized instrument was the MMSE (see Appendix E). The MMSE was developed by Folstein et al. (1975) for the purpose of assessing the cognitive abilities of an individual. The MMSE can be administered in approximately ten minutes, and requires a pencil, watch, and several sheets of loose-leaf paper. The MMSE has five sections that measure orientation, registration, attention and calculation, recall, and language. The test is usually administered by interview.

The purpose of using the MMSE in this study was two-fold. First, one of the inclusion criteria required that the subject be able to perform a simple three-step command. The ability to follow commands is assessed in the language portion of the MMSE. Second, the summary scores on the MMSE were used as a component of the descriptive data of the sample.

The second standardized instrument that was used in this study was the Barthel Index (Mahoney and Barthel, 1965) (see Appendix J). This ten-item test was developed to provide a means for scoring a patient’s ability to care for herself. Each item is scored on the basis of whether the subject is independent or needs assistance with the activity. Scores for items in which the patient needs assistance range from zero to ten, while scores for items in which the patients are independent range from five to 15. The purpose of the Barthel Index in this study was to classify the subjects according to degree of independence in basic activities of daily living.

The third standardized instrument that was used is the Tinetti Balance and Mobility Assessment (see Appendix A). This tool was selected because it is a performance oriented
mobility assessment that measures functional balance and is predictive of fall risk in the elderly (Tinetti et al., 1986). Mary Tinetti presented the Tinetti Balance and Mobility Assessment in the Journal of the American Geriatrics Society in 1986. This assessment tool is composed of 16 items. Nine items fall under the balance sub-scale, and the remaining seven items fall under the gait sub-scale. Each item is scored either on a two-point scale (0 - 1) or a three point scale (0 - 2). There is a maximum of 16 points for the balance sub-scale, and 12 points for the gait sub-scale. The maximum summary score is 28 points. Items on the balance portion are scored based on the subject’s ability to perform the tests continuously, steadily, or without any compensation. Items on the gait portion are graded according to whether a subject demonstrates certain gait characteristics or not.

The Tinetti Balance and Mobility Assessment is a simple and quick test to administer. It takes approximately ten to fifteen minutes and requires only an armless chair, watch, pen, and a 20 foot area in which to walk.

The Tinetti Balance and Mobility Assessment has also been proven reliable and valid in several studies. Researchers have reported an interrater reliability of .95 for the combined score of the gait and balance sub-scales (Tinetti et al., 1993). Berg et. al. (1992) reported concurrent validity between the balance sub-scale and the Berg Balance scale. In the study by Berg et al. (1992) higher Berg Balance Test scores were associated with higher balance sub-scale scores on the Tinetti Balance and Mobility Assessment (r = .91).

Predictive validity of the Tinetti Balance and Mobility Assessment has been reported in several studies for its ability to identify elderly individuals who are at risk for falling. Tinetti et al. (1986) reported that 76% of recurrent fallers in an institutionalized
population had a summary score of less than 19 points on the Tinetti Balance and Mobility Assessment. Tinetti et al. (1993) also reported that poor balance and gait performance characterized subjects, who had fallen and were able to get up, as 1.4 times more likely to fall again than those who had never fallen. Similarly, poor balance and gait performance characterized those subjects who had fallen, but were unable to get up, as two times more likely to fall again than subjects who had never fallen. Furthermore, Robbins et al. (1989) reported that a low score on the balance portion of the Tinetti Balance and Mobility Assessment predicted fall risk in a group of institutionalized elderly. Topper et al. (1993) had similar findings in a study of elderly subjects living in a residential care facility. This study reported, however, that the summary score was equally valid in predicting fall risk (Topper et al., 1993).

**Procedures**

As previously stated, an informational meeting was presented to the residents of Michigan Christian Home. The residents were provided with information regarding the purpose of the study, the potential benefits, and what would be required of them. Subject participation was voluntary and based on whether or not the individual met the eligibility requirements.

Those individuals interested in participating in this study were invited to attend the screening process. Activities that occurred during the screening process included: (a) explanation of the study and the tool that was used to measure functional balance (see Appendix A), (b) explanation of the safety measures that were implemented, (c) signing of the informed consent form (see Appendix D), (d) assessment of independence in activities
of daily living by interview (see Appendix J), (e) assessment of cognitive status (see Appendix E), (f) assessment of the individual's ability to independently walk a minimum of 40 feet with or without an assistive device, and (g) completion of the pre-assessment questionnaire (see Appendix F). Verification of the individual's past medical history was completed by the researchers through a review of portions of the individual's medical record. Each individual was also assigned a number so that her identity remained confidential throughout the remainder of the study. This number was used on all subsequent forms. Those persons who met the qualifications for this study were then allowed to participate in the testing phase. Each individual signed up for an appointment lasting not longer than 60 minutes.

For the testing phase, each subject was asked to bring a pair of their own shoes and slippers that met the operational definitions for this study. These definitions were presented during the informational meeting and screening process. Slippers were provided by the researchers when a subject did not have their own. Adjusted heel height (measured in centimeters) of the shoes was measured to provide a means of describing the type of shoes worn by the participants. Adjusted heel height was calculated by subtracting the height of the shoe sole at the first metatarsal head from the height of the most posterior aspect of the shoe sole at the heel. Shoe tread was placed into four categories: non-treaded/minimally worn, non-treaded/worn, treaded/minimally worn, and treaded/worn. In order to randomize the order of footwear worn by the subjects, three cards labeled with either shoe, slipper, or barefoot were shuffled and placed upside down before the subject. The subject was then asked to choose the cards in any order. The order in which the cards
were chosen determined which condition of footwear was examined first, second, and third.

Following the determination of order of footwear, subjects performed the Tinetti Balance and Mobility Assessment. Subjects performed each of the three trials only once and were encouraged to use any assistive device or brace that they would normally use. One researcher read the instructions for the Tinetti Balance and Mobility Assessment, while another researcher observed the subject, monitored the timing of items, and scored each item. The remaining researcher guarded the patient to prevent any falls from occurring. No medical emergencies occurred during the study; however, the researchers were aware of the procedures specific to the nursing home in the event of an emergency.

Each subject performed the balance sub-scale of the Tinetti Balance and Mobility Assessment first, followed by the gait sub-scale. This was in agreement with the standardized order of test items. Participants were informed prior to testing that they could rest between trials and could request a rest period as needed. Number and duration of rest periods were documented for each subject as a means of documenting the occurrence of fatigue. However, only one subject, a resident of the ALC, requested a rest break following each trial. All of the data gathered on each subject were recorded on a comprehensive recording sheet (see Appendix I).

Data Analysis

Balance, gait, and summary scores for the Tinetti Balance and Mobility Assessment were analyzed using a parametric test. This type of statistical test is appropriate as the summary score of the Tinetti Balance and Mobility Assessment is an
example of interval data. The parametric test that was used to analyze the data is the one-way repeated measures analysis of variance (ANOVA). This statistical test is appropriate to use with a one-way repeated measures design (Portney and Watkins, 1993). The ANOVA test analyzed the main effect of each footwear condition, the main effect of the subjects, and the interaction between these two variables. A post-hoc analysis using a paired t-test was performed to determine which condition of footwear was statistically significant. Differences between the subject's summary score for each footwear condition were significant at an alpha level of 0.05. Also, descriptive statistics were calculated in order to describe the sample cohort.
CHAPTER 4
ANALYSIS OF DATA

Subject Characteristics

Twenty-one female subjects from Michigan Christian Home were enrolled in this study; however, only nineteen subjects were included. Two subjects were excluded secondary to diagnosis of Parkinson’s Disease and residual deficits from a cerebral vascular accident. Eighteen of the nineteen subjects resided in the Home for the Aged, in which individuals are considered institutionalized but independent with self-care activities. Meals and housecleaning services are provided for the Home for the Aged residents. One subject resided in the Assisted Living Center, which provides twenty-four hour nursing supervision and assistance with some self-care activities. Mean number of months for length of residence at the nursing home was 51.6 (SD = 46.7) months, ranging from five to 216 months per resident. Subjects had a mean age of 84.4 (SD = 4.50) years, ranging from 79 to 94 years of age. Their cognitive and functional abilities were measured using the Mini-Mental State Examination (MMSE) and the Barthel Index. For the MMSE, the subjects had a mean score of 27.4 out of 30 points (SD = 2.45) with a range of 21 to 30 points. On the Barthel Index, the mean score was 94.7 on a 100 point scale (SD = 7.35) with the scores ranging from 70 to 100 points. Based on the Barthel index questionnaire, 47% of the subjects were fully independent in all activities of daily living (ADL’s), 37% required assistance with one ADL, and 16% required assistance for two or more ADL’s.

Two of the nineteen subjects reported using an assistive device. One participant used a 3-wheeled walker, and the other used a unipose cane only in the morning. All subjects ambulated independently with or without an assistive device in the nursing home.
Sixteen of the nineteen subjects were independent community ambulators. Orthotic shoe inserts were used by three of the nineteen subjects.

Subjects wore a variety of shoe types that were accepted into the study. Adjusted heel height was measured on each subject’s shoe. The mean height was 1.28 cm (SD = .70 cm) with measures ranging from 0 to 3.3 cm. Data describing the type of shoe, the condition of the sole surface, the type of slipper, and the most common type of footwear worn were collected from the subjects and are presented in Table 1.
### Table 1

**Characteristics of Shoes and Slippers Worn During Testing**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
<th>Number (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shoe Type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tennis Shoe (laces/velcro)</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>SAS (laces/slip-on)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Dress (laces/slip-on)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Other (boot/canvas)</td>
<td>2</td>
</tr>
<tr>
<td><strong>Sole Condition</strong></td>
<td>Treaded, minimally worn</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Treaded, worn</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Non-treaded, minimally worn</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Non-treaded, worn</td>
<td>1</td>
</tr>
<tr>
<td><strong>Slipper Type</strong></td>
<td>Slip-on, snug fit (non-skid soles)</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Slip-on, snug fit (smooth soles)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Slip-on, loose fit (smooth soles)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Flip-flop (non-skid soles)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Knitted slip-on</td>
<td>1</td>
</tr>
<tr>
<td><strong>Most Common Type Of Footwear Worn</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoe with laces</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Slip-on</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Low Heel Strap</td>
<td>1</td>
</tr>
</tbody>
</table>
Seven of the 19 subjects in this study reported a history of falls in the past year. Fifty-seven percent of these with a fall history had experienced one fall in the last 12 months and 43% had experienced two or more (recurrent) falls in the last 12 months. Only two of the reported falls had resulted in an injury. Table 2 shows the mean scores and standard deviations of the Tinetti Balance and Mobility Assessment for the fallers and the non-fallers in each footwear condition. Information presented in table 2 is depicted graphically in figure 1.

Table 2

<table>
<thead>
<tr>
<th>Footwear Type</th>
<th>Fallers</th>
<th>Non-fallers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M (SD)</td>
</tr>
<tr>
<td>Shoes</td>
<td>7</td>
<td>21.7 (5.68)</td>
</tr>
<tr>
<td>Barefoot</td>
<td>7</td>
<td>20.4 (5.19)</td>
</tr>
<tr>
<td>Slippers</td>
<td>7</td>
<td>19.7 (6.37)</td>
</tr>
</tbody>
</table>

Figure 1. Mean summary scores for fallers (n=7) and non-fallers (n=12) in each footwear condition.
Subjects in this study were taking from zero to eight prescription medications with a mean of 3.2 (SD = 2.29) medications per person. A variety of co-morbid diagnoses also existed within the sample. The type and prevalence of co-morbid diagnoses, as well as subjects’ pertinent medical history are listed in Table 3.

Table 3

<table>
<thead>
<tr>
<th>Active list of Co-Morbid Diagnoses</th>
<th>Number</th>
<th>Pertinent Medical History</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>11</td>
<td>Transient Ischemic Attack</td>
<td>3</td>
</tr>
<tr>
<td>Arthritis</td>
<td>6</td>
<td>Total Hip Arthroplasty</td>
<td>3</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>2</td>
<td>Hip Fracture</td>
<td>3</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>2</td>
<td>Total Shoulder Arthroplasty</td>
<td>2</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>2</td>
<td>Spinal Compression Fracture</td>
<td>2</td>
</tr>
<tr>
<td>Right eye implant</td>
<td>1</td>
<td>Myocardial Infarction</td>
<td>2</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1</td>
<td>Total Knee Arthroplasty</td>
<td>1</td>
</tr>
<tr>
<td>Angina</td>
<td>1</td>
<td>Humerus Fracture</td>
<td>1</td>
</tr>
<tr>
<td>Retinal Degeneration</td>
<td>1</td>
<td>Positional Vertigo</td>
<td>1</td>
</tr>
<tr>
<td>Arteriosclerosis</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary Artery Disease</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiomegaly</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All subjects completed the Tinetti Balance and Mobility Assessment for each of the three footwear conditions. The sample mean and range of scores for each condition are
listed in Table 4. Summary and sub-scale scores for gait and balance are represented in
the table. The information presented in table 4 is depicted graphically in figure 2.

Table 4

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>Balance M (SD) [Range]</th>
<th>Gait M (SD) [Range]</th>
<th>Summary M (SD) [Range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoe</td>
<td>19</td>
<td>13.5 (2.38) [9 - 16]</td>
<td>11.2 (1.90) [4 - 12]</td>
<td>24.5 (4.06) [10 - 28]</td>
</tr>
<tr>
<td>Barefoot</td>
<td>19</td>
<td>12.7 (2.33) [5 - 16]</td>
<td>10.8 (1.89) [5 - 12]</td>
<td>23.6 (4.03) [10 - 28]</td>
</tr>
<tr>
<td>Slipper</td>
<td>19</td>
<td>12.1 (2.56) [4 - 16]</td>
<td>10.7 (2.35) [2 - 12]</td>
<td>22.8 (4.61) [6 - 28]</td>
</tr>
</tbody>
</table>

Figure 2. Mean scores of the balance and gait sub-scales and the summary scores in each footwear condition.
Reliability

A single rater scored the Tinetti Balance and Mobility Assessment for all subjects in each footwear condition. To examine the test-retest reliability with this rater, six subjects were re-tested on the Tinetti Balance and Mobility Assessment within two weeks following the completion of the data collection. Data was analyzed using the Pearson product-moment correlation test. This time frame was long enough to avoid the carry-over of learning or memory effects, yet short enough to reduce the likelihood of a significant change in physical function. These subjects performed the test wearing the footwear type that they wore previously in the first trial. Analysis of the data revealed that the rater was reliable under test-retest conditions with \( r = .89 \). This was significant at \( p < .05 \) (\( p = .018 \)).

Analysis of Functional Balance in Different Footwear Conditions

A single factor analysis of variance (ANOVA) with repeated measures was used to determine whether there was a significant difference in the Tinetti summary scores and the balance and gait sub-scores between the three footwear conditions. Results were determined to be significant at a level of \( p< .05 \). Results of the ANOVA for the balance and summary scores revealed a significant difference. However, the ANOVA for the gait sub-scale revealed no significant difference. Summary of the ANOVA is presented in table 5.
Table 5

Summary of Analysis of Variance for Summary Scores in each Footwear Condition

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance Score</td>
<td>9.51</td>
<td>2</td>
<td>4.75</td>
<td>5.61</td>
<td>.008*</td>
</tr>
<tr>
<td>Gait Score</td>
<td>1.51</td>
<td>2</td>
<td>.75</td>
<td>1.96</td>
<td>.155</td>
</tr>
<tr>
<td>Summary Score</td>
<td>17.93</td>
<td>2</td>
<td>8.96</td>
<td>6.45</td>
<td>.004*</td>
</tr>
</tbody>
</table>

* significant at p < .05

A post-hoc analysis was performed to determine if the shoe condition resulted in significantly better scores than the slipper or barefoot conditions. A two-tailed paired t-test was used for this post-hoc analysis. This analysis revealed that in the shoe condition, subjects had significantly higher summary scores than in the barefoot and slipper conditions. However, when comparing the barefoot and slipper conditions, neither was found to have significantly higher scores. A summary of the paired t-test results are presented in table 6.

Table 6

Summary of the Paired t-test results for Comparing Summary Scores of each Footwear Condition

<table>
<thead>
<tr>
<th>Variable</th>
<th>t</th>
<th>DF</th>
<th>2-tailed Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoe vs. Barefoot</td>
<td>-2.17</td>
<td>18</td>
<td>.043*</td>
</tr>
<tr>
<td>Shoe vs. Slipper</td>
<td>3.20</td>
<td>18</td>
<td>.005*</td>
</tr>
<tr>
<td>Slipper vs. Barefoot</td>
<td>1.64</td>
<td>18</td>
<td>.118</td>
</tr>
</tbody>
</table>

* Significant at p < .05
The alternative hypothesis of this study stated that subjects would score better on the Tinetti Balance and Mobility Assessment in the shoe condition when compared to the barefoot and slipper conditions. As the results indicate, the alternative hypothesis was accepted. Consequently, the null hypothesis, which stated that there would be no significant difference in the summary score between footwear conditions, was rejected.

Physical function and cognitive abilities are factors that influence frailty (Brown et al., 1995). Therefore, data was further analyzed, using the Pearson product-moment correlation test, to determine if a correlation existed between the following: 1) Summary score for each footwear condition and MMSE, 2) Summary score for each footwear condition and Barthel Index. Results were significant at p<.05. No significant correlation was found between the summary scores for the Tinetti Balance and Mobility Assessment and MMSE. However, a significant positive correlation existed between the Barthel Index scores and each of the summary scores for shoe, barefoot, and slipper conditions (r = .6735, .6424, .7203, respectively). These values indicated a moderate to good degree of relationship (Portney and Watkins, 1993).

Frailty has been reported to be independent of age; therefore, the researchers analyzed the following data, using a Pearson Product-moment correlation coefficient, to determine if that statement held true for this study's sample: 1) MMSE and age, 2) Barthel Index and age, and 3) Summary score for each footwear condition and age (Brown et al., 1995). No significant correlation was found for any of the above comparisons at a level of p < .05. A summary of correlation coefficients is presented in table 7.
Table 7

Correlation Between Subject Characteristics and Summary Scores in Different Footwear Conditions
(df = 18, n = 19)

<table>
<thead>
<tr>
<th>Tinetti Balance and Mobility Assessment</th>
<th>Shoes</th>
<th>Barefoot</th>
<th>Slippers</th>
<th>MMSE</th>
<th>Barthel</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE</td>
<td>-.0850</td>
<td>-.0758</td>
<td>-.1069</td>
<td>-</td>
<td>-.3804</td>
<td>.1199</td>
</tr>
<tr>
<td>Barthel</td>
<td>.6735*</td>
<td>.6424*</td>
<td>.7203*</td>
<td>-.3804</td>
<td>-</td>
<td>-.0473</td>
</tr>
<tr>
<td>Age</td>
<td>-.1721</td>
<td>-.0737</td>
<td>-.1296</td>
<td>.1199</td>
<td>.0473</td>
<td>-</td>
</tr>
</tbody>
</table>

* = significant at P < .05
CHAPTER 5
DISCUSSION

Interpretation of Sample Characteristics

The sample used in this study is unique when compared with other samples of institutionalized elderly. Although the subjects were categorized as institutionalized, they did not exhibit many of the characteristics that are commonly associated with institutionalized and frail elderly. Scores on the Barthel Index indicated that the majority of the sample was independent in basic activities of daily living. The ability to ascend and descend a flight of stairs was commonly cited as the only activity that the subject required assistance with or was unable to perform. The majority of the sample was also independent with community ambulation and required no assistive device. The degree of functional decline in the sample was relatively minimal, which was surprising given the high mean age of 84.4 years. Furthermore, review of the medical records of the sample revealed very few co-morbid diagnoses. Overall this cohort exhibited characteristics more commonly associated with well elderly rather than frail and institutionalized elderly.

Interpretation of Findings

The primary purpose of this study was to examine the relationship between three footwear conditions and functional balance in a population of institutionalized elderly women using the Tinetti Balance and Mobility Assessment. The hypothesis was that functional balance, as measured by the Tinetti Balance and Mobility Assessment, would be significantly better in the shoe condition as compared to the slipper or barefoot conditions. Statistical analysis of the data supports this hypothesis. A significant difference was found
between the three footwear conditions using the summary scores from the Tinetti Balance and Mobility Assessment. A post-hoc analysis revealed that functional balance performance was superior for subjects when wearing shoes as compared to slipper or barefoot conditions.

Results from this study are consistent with previous studies. The study by Robbins et al. (1992) supports our findings. They found, in a sample of 25 men age 60 and older, that subjects ambulated on a balance beam significantly better when wearing shoes as compared to the barefoot condition (p<0.0001). Lord and Bashford’s (1996) findings also support the results of our study. They studied a cohort of 30 elderly women who were asked to perform static and dynamic balance activities in four different footwear conditions. The researchers found that subjects demonstrated superior performance on the maximum balance range test when wearing low-heeled shoes. The maximum balance range test, a dynamic balance activity, assesses the maximum distance a participant can move in the forward and backward direction without moving his feet or losing his balance. It may be inappropriate, however, to compare the findings of Lord and Bashford with the results of our study because of the non-functional testing methods employed by Lord and Bashford. In contrast, our study provides strong support for clinical and practical recommendations due to the functionally oriented assessment tool that was used.

Our study also makes an important contribution to the existing literature due to the age characteristics of the sample. Among the three other studies that have examined the relationship between footwear and functional balance in the elderly, this is the only study to date that has examined a cohort of very old, institutionalized elderly. The age of participants in this study ranged from 79-94 years with a mean age of 84.4 years (SD=
The research by Lord and Bashford (1996) is the only other known study of this nature that comes close to comparison in terms of the subjects' age and residential status. Lord and Bashford (1996) conducted research with 30 subjects with a mean age of 78.8 years (SD= 8.5). Furthermore, all but five of the subjects resided in a similar living environment to that of the subjects in our study. However, Lord and Bashford (1996) failed to use a functional assessment of balance. Our study is important primarily because it is one of the first studies to examine the relationship between footwear and functional balance with a cohort of older elderly. Also, it provides important evidence that a simple entity, such as footwear, can have significant effects on the functional balance of an institutionalized and frail population of elderly.

In addition to the analysis of the summary scores, balance and gait sub-scale scores were also analyzed. The balance sub-scale scores showed a significant change between the three footwear conditions. However, there was no significant difference in gait sub-scale scores between the footwear conditions. A possible explanation for why the gait sub-scale failed to show a significant difference between the three footwear conditions may be due to the design of the scoring system. The gait sub-scale of the Tinetti Balance and Mobility Assessment consists of seven items. Five of the seven items allow for only a score of zero or one. This type of dichotomous scoring may not allow for subtle changes in gait quality, as a result of footwear, to be quantified.

Perhaps a comprehensive gait assessment tool with a more sensitive scoring system would have found significant differences between footwear conditions. For example, the Gait Assessment Rating Scale (GARS) is a 16 item measurement tool that allows for a rating from 0-3 for each of the 16 items. A scale of this type may allow for more subtle
changes in gait to be detected. The GARS has also been shown to be a sensitive indicator of changes in gait function among older adults (Shumway-Cook and Woollacott, 1995). The scoring criteria and the limited number of items scored with the Tinetti Balance and Mobility Assessment provide a probable explanation for the insignificant findings when analyzing the gait sub-scale in isolation.

Analysis of the data failed to establish a significant difference between the slipper and barefoot conditions. To date, there have been no controlled published inquiries in regard to performance on functional balance measures when wearing slippers. Nor has there been research that compares slipper to barefoot conditions on functional balance tasks. Some researchers have made recommendations that slippers are not an appropriate or safe footwear for the elderly, but there are no studies controlling for slippers that would uphold or provide support for this statement (Robbins et al, 1992; Rubenstein et al., 1988; Sehested and Severin-Nielsen, 1977; Tinetti and Speechly, 1989). There are several explanations as to why our study failed to provide strong support for or against this recommendation. Most importantly, there was a great deal of variability among the types of slippers that were worn by the participants. The slippers all met the operational definition of footwear having a smooth or non-skid sole without any type of fastener, but the degree of support provided by the slippers varied considerably. To illustrate the degree of variability, one participant’s slippers were of a homemade, knitted slip-on design compared to another participant’s sturdy, well-constructed slip-on slippers. There was also some degree of variability in the barefoot condition. Several participants were unwilling to perform the activities totally barefoot and insisted on leaving their nylon stockings on. At the time of data collection, the researchers felt that this difference would
be negligible, but perhaps this was not a completely accurate assessment. Nevertheless, the researchers were not able to infer from the statistical analysis which footwear condition, slipper or barefoot, led to the poorest functional balance performance.

Perhaps, however, there is no real difference in functional balance between slipper and barefoot conditions. With the elderly, the difference may be between shoes and no shoes. Footwear serves as a support area for the body (Finlay, 1986). If the support area is unstable or inadequate then the static and dynamic stability of an older person may be compromised (Finlay, 1986). The question that must be posed is why do shoes positively impact an elderly individual’s functional balance? One theory is that shoes may provide a biomechanical advantage. Because of their construction/design, shoes tend to provide a wider and more level base of support. This may be especially advantageous to the elderly because of structural changes and/or deformities that are commonly seen in their feet (Finlay, 1986).

It is important to also determine whether or not the results of this study are clinically meaningful. When looking at the differences between mean summary scores for the three footwear conditions, there is a 0.9 difference between the mean summary scores for shoe and barefoot conditions and a 1.7 difference in mean summary scores between shoe and slipper conditions (see Table 4). Although this difference is small in clinical terms, it may still be meaningful when applied to an individual whose fall threshold is extremely low due to a variety of other concurrent intrinsic and extrinsic fall risk factors.

The means and standard deviations of the summary scores were also calculated in an attempt to compare two sub-groups within the sample. The mean summary scores were calculated for the Tinetti Balance and Mobility Assessment for each of the three
footwear conditions between the fallers (N= 7) and the non-fallers (N=12) (see Table 2). Categorization of a faller was based on self-report of a fall occurring within the 12 months preceding this study. Descriptive analysis of the data revealed that the fallers had an overall lower mean summary score for all three conditions when compared to the non-fallers. This finding, however, is weakened by the degree of variability among the fallers’ summary scores, as evidenced by the high standard deviations (see Table 2). With removal of one outlier, the variability in the summary scores of the fallers decreased, yet the trend for lower mean summary scores in fallers compared to non-fallers was still evident (see Table 8).

Table 8

Mean Summary Scores and Standard Deviations of Fallers with Outlier and without Outlier in each Footwear Condition

<table>
<thead>
<tr>
<th>Footwear Type</th>
<th>Fallers with Outlier</th>
<th>Fallers without Outlier</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>Shoes</td>
<td>7</td>
<td>21.7</td>
</tr>
<tr>
<td>Barefoot</td>
<td>7</td>
<td>20.4</td>
</tr>
<tr>
<td>Slippers</td>
<td>7</td>
<td>19.7</td>
</tr>
</tbody>
</table>

It is important to examine the one outlier as the high degree of variability may be explained by her extremely poor performance. This participant, a resident of the Assisted Living Center, reported two falls in the previous 12 months. She also reported the lowest functional level with a Barthel Index score of 70, and scored the lowest summary score in each of the three footwear conditions. Her summary scores for the shoe, slipper, and
barefoot conditions were 10, 6, and 10, respectively. The fact that her scores for the shoe and barefoot conditions were the same, which was not consistent with the rest of the sample, may be explained by the degree of fatigue that she experienced. She required an average rest break of 113 seconds in between trials; whereas, the majority of the sample required no rest break at all. She also performed in the slipper condition last. Overall, the performance of this participant provides insight into the significant effect that footwear can have on functional balance in a frail elderly individual with a notable degree of functional decline. With a more frail population of elderly, as with this individual, footwear choice may be the additional factor that could cause the individual to exceed their fall threshold. By examining the differences between fallers and non-fallers, there is an apparent trend with fallers demonstrating poorer performance on the Tinetti Balance and Mobility Assessment. This trend is similar to the findings of other researchers who have shown significant differences between fallers and non-fallers when using the Tinetti Balance and Mobility Assessment or a modified version of this tool (Lipsitz et al., 1992; Robbins et al., 1996; Topper et al., 1993).

Clinical Implications

Indirectly, this study provides support for the importance of addressing footwear as an extrinsic risk factor in fall prevention programs for the elderly. The Tinetti Balance and Mobility Assessment has been shown to be predictive of fall risk in the elderly (Robbins et al., 1989; Tinetti et al., 1986). By establishing that footwear affects the score of the Tinetti Balance and Mobility Assessment, an indirect link can then be made between footwear and fall risk. Through data analysis, it was shown that subjects performing in the
shoe condition had significantly superior summary scores. A superior or higher summary score can be interpreted to mean that the subject’s functional balance is better. Consequently, better functional balance contributes to a decrease in the risk for falls (Tinetti et al., 1986). The findings of this study provide support for the recommendations in the fall-related literature that encourage elderly individuals to wear shoes and avoid walking barefoot or in slippers. This recommendation may be especially important when working with an elderly individual who has a history of falls, is at a great risk for falling due to concurrent intrinsic risk factors, or with one who is interacting in a potentially threatening environment. For example, footwear may be a key factor that leads an elderly person to exceed their fall threshold when moving in an environment with low lighting, unlevel surfaces, or plush carpeting.

Furthermore, this study provides support for the increased awareness of footwear considerations in the frail and institutionalized elderly by their healthcare professionals and caregivers. Caregivers should be cognizant of the potential degradation of an elderly person’s functional balance in slipper or barefoot conditions during basic activities of daily living and leisure. Staff of nursing homes should be encouraged to educate elderly residents on the importance of choosing appropriate footwear and play an active role in monitoring and addressing potentially hazardous footwear choices.

Finally, this study provides support for the standardization of the Tinetti Balance and Mobility Assessment in regard to footwear. The results of this study show that footwear does significantly alter the summary scores. Based on the findings of this study, clinicians should have their patients wear shoes when performing the test, which would allow for evaluation of the individual’s optimal balance performance. If clinicians choose
not to evaluate a subject’s performance with shoes on, then they should document type of footwear worn and at least be consistent with footwear when performing the Tinetti Balance and Mobility Assessment. Failure to do this could result in inconsistent and unreliable scores. This inconsistency in scoring would be most problematic when using the tool as an outcome measure because a change in score would not only reflect the intervention but possibly the alteration in footwear.

Commentary on the Tinetti Balance and Mobility Assessment

The researchers of this study chose the Tinetti Balance and Mobility Assessment because it measures functional balance, has been proven reliable as a fall risk indicator, and is easy to administer. The researchers believe that this test was an effective tool for measuring functional balance. The balance sub-scale seemed to be more sensitive to changes in footwear conditions than did the gait sub-scale. Subjects appeared to have more difficulty performing items two, three, four, five, and six in barefoot and slippers (see Appendix A). These items scored the ability to arise out of a chair, the number of attempts needed to stand up, their immediate and static standing balance, and their ability to withstand three nudges to the sternum. A possible explanation for increased difficulty with these test items in the slipper and barefoot conditions could be because shoes provided better support and, thus, a more stable base upon which to stand. Also, several subjects commented to the researchers that they felt more confident wearing shoes and rarely walked around barefoot or in slippers. Items one, seven, eight, and nine did not seem to be sensitive to the change in footwear condition. Sitting balance did not seem to be affected by different footwear, as all subjects were steady and safe while sitting
regardless of footwear condition. Item seven required subjects to close their eyes with their feet as close together as possible. Very few subjects were unsteady in this position and a change in footwear did not alter their scores. Surprisingly, footwear also did not seem to affect the subjects’ ability to turn 360 degrees or to sit down (items eight and nine). An explanation for these findings could be that these tasks were too simple for many of the participants and the change in footwear condition did not provide a stressful enough alteration to require the subjects to use alternate strategies.

The gait sub-scale of the Tinetti Balance and Mobility Assessment was not as sensitive to changes in footwear condition as the balance sub-scale. The focus of this portion of the assessment tool was not on challenging the subjects’ ability to ambulate, but on assessing gait deviations. The majority of our subjects ambulated without great difficulty; therefore, they had very slight gait deviations. Similar to items one, seven, eight, and nine of the balance sub-scale, the gait sub-scale did not challenge the subjects’ walking abilities to such a degree where the influence of footwear would become evident. Subsequently, the participant’s scores tended to be high on the gait sub-scale.

**Potential Threats to Reliability**

The Tinetti Balance and Mobility Assessment was found to have high test-retest reliability in this study. Yet over the course of the study, several potential threats to the reliability of the Tinetti Balance and Mobility Assessment were discovered by the researchers. First, instructions on how to score the Tinetti Balance and Mobility Assessment were vague, which left the researchers to make interpretations on how some of the items should be scored. For example, while assessing step length and height on the
gait sub-scale, the instructions require the swing foot to pass the stance foot and to clear the floor during swing phase. The instructions do not state how often these criteria must occur over the course of the trial. The scorer, therefore, interpreted the instructions to mean that any deviation must occur consistently over the gait cycle, not just during an isolated incident when the subject might have accidentally stumbled. Also, the use of arms while arising from sit to stand was not clearly defined. Prior to data collection, the researchers considered a subject to be "using arms" only when pushing off of the chair. As the researchers practiced before data collection began, they realized that often individuals push off of their knees to aid in standing up. Therefore, during the data collection the scorer considered pushing off of the chair or legs to qualify as using arms.

A second observation was that the Tinetti Balance and Mobility Assessment allows for a great deal of subjectivity in the scoring. Activities such as stance width during standing and gait, and sway of the trunk during gait required the scorer to make a subjective evaluation of any deviations.

Finally, item six on the balance sub-scale presented a potential problem in terms of consistency. Item six required one of the researchers to nudge the subject on the sternum in an attempt to displace her equilibrium. While the researcher who assisted with this portion of the test attempted to apply the same amount of pressure with each subject, there was no mechanism to objectively quantify the amount of force used. Despite these criticisms, the Tinetti Balance and Mobility Assessment was found reliable in this study and is still a useful clinical tool. It is simple, quick, inexpensive, and provides an accurate assessment of general balance deficits in the elderly.
In order to minimize the potential threats to the reliability of the Tinetti Balance and Mobility Assessment, the researchers attempted to standardize the scoring and administration of the test. First, questions on interpretation of the scoring were settled prior to data collection in order to ensure consistency. Second, each researcher had an assigned role, thus only one researcher scored the subjects' performance. One researcher read the instructions to each subject while the remaining researcher guarded each subject during each trial. These procedures aided in improving the reliability of the Tinetti Balance and Mobility Assessment.

**Limitations of the Study**

The limitations of this study can be categorized into five general areas. These areas include rater limitations, sample size, site characteristics, limitations within the trial, and the operational definitions set in this study.

The rater used in this study was a third-year graduate student in physical therapy with twenty-six weeks of clinical experience. While the rater was trained in the use of the Tinetti Balance and Mobility Assessment, his clinical experience was limited with the tool. However, test-retest reliability with the student rater was shown to be reliable ($r=0.89$). A study conducted by Cipriany-Dacko, Innerest, Johannsen, and Rude (1997) supports the reliability of student raters. Cipriany-Dacko et al. (1997) reported that students with six weeks of clinical experience were shown to have good interrater reliability with the balance sub-scale of the Tinetti Balance and Mobility Assessment when compared to clinicians with experience. In the study, the reliability of three student physical therapists was compared to that of nine physical therapy clinicians with varied clinical experience.
The student physical therapists demonstrated fair to excellent $k$ coefficients (.4-1.00). The experienced clinicians, with a broad range of clinical experience, demonstrated fair to good $k$ coefficients (.4-.75).

Another limitation of this study was that the rater of interest was an author of the study, and therefore could not be blinded as to the research hypothesis. This bias is a significant limitation as the rater was aware of each different footwear condition while scoring the subjects’ performance. Although researcher bias was not intentional, it was an element of the design that must be included as a limitation. Further research could utilize raters that are blinded to the research hypothesis to score each subject’s performance. This would eliminate the rater bias.

Another significant limitation of this study was the small sample size and characteristics of the sample. Nineteen subjects participated in this study, all of whom were women. Small sample size limits the generalizability of the results. The fact that all nineteen participants were women may limit the application of this study’s findings to female elderly. However, support for the sample used in this study comes from the co-morbid diagnoses and medical history of the subjects, which was typical of the institutionalized elderly.

An additional limitation was the high mean age of the subjects in the study. Results may have been different in an elderly population whose mean age was significantly lower. Also, subjects were recruited from one local nursing home, with all but one subject residing in the Home for the Aged. This level of care at Michigan Christian Home provides meals and housecleaning for each resident, but does not provide twenty-four hour nursing supervision. Residents residing in the Home for the Aged are independent
with self-care. However, in the Assisted Living Center, from which one resident was recruited, twenty-four hour nursing supervision is provided and residents require minimal to moderate assistance with self-care. The fact that all but one subject resided in the Home for the Aged may limit the generalizability of the results to the more frail institutionalized elderly and also to community dwelling well-elderly.

The testing design used in this study also presents some limitations. The possibility of a learning effect occurring between the three trials was high. However, this limitation was addressed by randomizing the order of the three trials with each subject. This randomization also addressed the possible or potential effects of fatigue between trials. Fatigue, however, did not appear to be a factor with this sample as only the subject from the Assisted Living Center required significant rest breaks between trials.

A final limitation was the broad operational definitions of footwear established by the researchers. These definitions were broad so as not to exclude potential participants on the basis of not owning the appropriate footwear. The definitions were also chosen so that the footwear studied was the same footwear worn by the subjects on a daily basis. By choosing to use broad definitions of footwear, it is difficult to propose a clear-cut recommendation as to the best type of shoe to wear to improve functional balance. Further studies using more strictly defined operational definitions might serve to address this limitation.

**Further Research**

There are many areas in need of further research to support the findings of this study. The results of this study indicated, based on the Tinetti Balance and Mobility Assessment, that balance was more affected than gait by footwear. A study utilizing the
balance sub-scale of the Tinetti Balance and Mobility Assessment in conjunction with a more thorough gait analysis might be better able to catch subtle changes in gait due to different types of footwear. A more detailed gait analysis, such as the GARS, or an assessment with changing task demands, such as the Dynamic Gait Index, might better be able to detect subtle changes and provide evidence to support the effect of footwear on functional balance during walking.

The potential influence of footwear on balance in this study might be further illustrated if a more detailed measure of balance, such as the Berg Balance Scale, was used. The Berg Balance Scale has been shown to be highly reliable in measuring balance in the elderly (Russo, 1997). This scale offers a more detailed look at functional balance by assessing a variety of balance activities in both standing and sitting. The Berg Balance Scale is also graded on a four-point scale, which may make it more sensitive to change than the Tinetti Balance and Mobility Assessment. However, the Berg Balance Scale would have to be used with another gait assessment tool because it does lack a formal gait section.

Further research could also be done using more narrow definitions of shoes and slippers. This might offer more practical recommendations as to the most stable type of footwear for the elderly. Additionally, more specific types of footwear could be compared, such as athletic shoes or slip-ons, which would identify the best type of footwear within a category.

Other studies could utilize a similar research design and measurement tool, but look at a larger and more diverse sample. Subjects could be recruited from more than one nursing home to obtain a broader sample of institutionalized elderly. It would also be
interesting to look at community dwelling elderly to see if footwear affects their functional balance as well. Institutionalized elderly may be closer to the fall threshold and at a higher risk for falls than community dwelling elderly. Therefore, footwear may have more of an impact on the balance of the institutionalized elderly. A study comparing functional balance under different footwear conditions in community dwelling elderly to institutionalized elderly might also show if frailty has an effect on the results. The impact of frailty level could be further illustrated in a study comparing certain elderly populations within a nursing home, such as those living in assisted living environments to those living in a nursing care environment.

A prospective study addressing whether shoes really do minimize fall risk in the institutionalized elderly could aid in applying the findings of this study. Participants could be encouraged to wear shoes during any balance or ambulation activities while in the home or in the community. Each subject would then be required to submit a weekly log in which the number of falls are recorded. Continued support for the influence of footwear on functional balance would exist if a decrease in the number of falls was the outcome of such a prospective study.

This study has generated many ideas for further research. Further evidence of the effect of footwear on functional balance is necessary to support the recommendations brought forth by this study. Variations from this study, such as those mentioned above, would allow researchers to gain a better understanding of the role of footwear on functional balance and the importance of addressing footwear in fall prevention programs.
Conclusion

Results from this study revealed that footwear had a significant effect on functional balance, as measured by the Tinetti Balance and Mobility Assessment, in institutionalized female elderly. Subjects performed significantly better in the shoe condition as compared to the barefoot or slipper conditions. Because the Tinetti Balance and Mobility Assessment has been shown to be predictive of fall risk, this study supports the inclusion of footwear recommendations in fall prevention programs for institutionalized elderly. Footwear is an easily modifiable risk factor and therefore, could be readily addressed in fall prevention programs. Further research regarding balance and walking performance while controlling for footwear is needed to continue to support these recommendations.
REFERENCES


Tinetti, M.E., Williams, F., & Mayewski, R. (1986). Fall risk index for elderly patients based on a number of chronic disabilities. The American Journal of Medicine, 80, 429-434.


APPENDIX A
**Tinetti Balance and Mobility Assessment Form**

**Balance Tests**

Command: Please wait until all of the instructions are read before performing the task. You may ask to have the command repeated before beginning the task. Please have a seat in the chair.

1. **Sitting Balance**
   - Leans or slides in chair = 0
   - Steady, safe = 1
   
   Command: Please stand up and stay standing. You may do that now.

2. **Arises**
   - Unable, without help = 0
   - Able, uses arms to help = 1
   - Able, without using arms = 2

3. **Attempts to arise**
   - Unable, without help = 0
   - Able, requires > 1 attempt = 1
   - Able to arise, 1 attempt = 2

4. **Immediate standing balance (first five seconds)**
   - Unsteady (swaggers, moves feet, trunk sway) = 0
   - Steady, but uses walker or other support = 1
   - Steady, without walker or other support = 2

5. **Standing balance**
   - Unsteady = 0
   - Steady, but wide stance (medial heels > 4 in. apart) and use cane or other support = 1
   - Narrow stance without support = 2

6. **Nudged** (subject at maximum position with feet as close together as possible, examiner pushes lightly on subject’s sternum with palm of hand 3 times)
   - Begins to fall = 0
   - Staggers, grabs, catches self = 1
   - Steady = 2

   Command: Keeping your feet as close together as possible, close your eyes. Do not open them until I have instructed you to do so. You may do that now.

7. **Eyes closed** (at maximum position number 6)
   - Unsteady = 0
   - Steady = 1

   Command: You may now open your eyes. Turn around one time, in a complete circle. You may do that now.

8. **Turning 360 degrees**
   - Discontinuous steps = 0
   - Continuous = 1
   - Unsteady (grabs, staggers) = 0
   - Steady = 1

   Command: Please sit down in the chair. You may do that now.

9. **Sitting down**
   - Unsafe (misjudged distance, falls into chair) = 0
   - Uses arms, not smooth motion = 1
   - Safe, smooth motion = 2

   Balance Score: ______ / 16
Tinetti Balance and Mobility Assessment Form
Gait Tests

Command: Stand up and walk at your usual pace, to the cone. Once you've reached the cone, turn around and walk back to the chair at a rapid, but safe pace. You may then sit down. You may begin.

10. Initiation of gait (immediately after told to begin) Any hesitancy or multiple attempts to start = 0
(No hesitancy) = 1

11. Step length and height
   a. Right swing foot
      Does not pass the left stance foot with step = 0
      Passes left stance foot = 1
      Right foot does not clear floor completely with step = 0
      Right foot completely clears floor = 1
   b. Left swing foot
      Does not pass right stance foot with step = 0
      Passes right stance foot = 1
      Left foot does not clear floor completely with each step = 0
      Left foot completely clears floor = 1

12. Step symmetry
    Right and left step length not equal (estimate) = 0
    Right and left step appear equal = 1

13. Step Continuity
    Stopping or discontinuity between steps = 0
    Steps appear continuous = 1

14. Path (estimated in relation to floor tiles, 12 inch diameter; observe excursion of 1 foot over about 10 ft. of the course)
    Marked deviation = 0
    Mild/moderate deviation or uses walking aid = 1
    Straight without walking aid = 2

15. Trunk
    Marked sway or uses walking aid = 0
    No sway, but flexion of knees or back pain or spreads arms out while walking = 1
    No sway, no flexion, no use of arms, and no use of walking aid = 2

16. Walking time
    Heel apart = 0
    Heels almost touching while walking = 1

Gait Score: ______ / 12
Balance and Gait Score: ______ / 28
APPENDIX B
July 24, 1997

Michigan Christian Home
1845 Boston SE
Grand Rapids, MI 49506

Dear Mr. Wild:

My name is Stacey Jonkman, and I am a graduate student in physical therapy at Grand Valley State University, Allendale, Michigan. I am writing to you on behalf of myself and my research partners, Kristen Brooks and Matt Schmitz. As partial fulfillment of the requirements for a Master's degree in physical therapy, we must design and complete a Master's thesis. Previously, we contacted you in regard to using Michigan Christian Home as a study site for a small pilot study. However, we were able to negate the need for a pilot study based on a more thorough review of the literature. We are now preparing to begin our research project, and are currently seeking a site from which to draw our sample population. It is our hope that Michigan Christian Home would still be willing to serve as the primary study site for our research.

Enclosed you will find the following documents: 1) brief description of the study, 2) the informed consent form, 3) the Tinetti balance and mobility assessment, 4) the Folstein Mini-mental state examination, 5) the pre-assessment questionnaire, 6) the medical records confidentiality statement, and 7) the Barthel Index. These documents should give you a more clear picture of what this study will encompass. In regard to the use of medical records, we acknowledge that this is confidential information and will only access the records after informed consent is received from the participant. Only certain portions of the record will need to be examined, and these include medical history and prescription records. This information is important, as it will determine whether an individual meets all the requirements for this study.

We would like to thank you in advance for taking the time to review this material and for considering our request for assistance. Please understand that the formal process of conducting this study cannot be initiated prior to final approval from the Institutional Review Board at Grand Valley State University. Furthermore, we plan to begin the formal process of collecting data in late December and January.

If you have any questions or concerns, please feel free to contact us. I can be reached at (616) 245-4234, Kristen can be contacted at (616) 679-4504, and Matt can be contacted at (616) 667-1005. We would also be very willing to meet with you, at your convenience, to further discuss this study. We look forward to hearing from you.

Sincerely,

Stacey Jonkman
APPENDIX C
Study Description

Purpose: The purpose of this study is to examine the relationship between footwear and functional balance in a population of institutionalized elderly. More specifically, shoe, slipper, and barefoot conditions will be studied. Footwear has been cited in the literature as an environmental factor that may precipitate a fall in an elderly individual. Further research is needed, however, to clarify the impact that footwear may have on an individual’s ability to maintain balance, and therefore decrease the risk of falling.

Subject Selection and Eligibility: Subjects for this study will participate strictly on a voluntary basis. A brief synopsis of the study, which will include eligibility requirements, will be given to the residents of Michigan Christian Home. An appropriate time and location for the introduction of this study will be determined by the administration of Michigan Christian Home and the researchers. At a later date, all interested residents will be invited to attend an informational meeting and begin the screening process. To be eligible for this study, the individual must be 1) age 65 or older, 2) a resident of Michigan Christian Home, 3) demonstrate the ability to follow a three step command, and 4) demonstrate the ability to walk a minimum of 40 feet on a level surface independently or with the aid of an assistive device (i.e. cane, walker) or brace. Exclusion criteria identified by this study include history of any or all of the following: 1) amputations of the leg or foot, 2) Parkinson’s disease, 3) stroke or traumatic brain injury with residual deficits, 4) vestibular disease, 5) multiple sclerosis or other neurological disorders, 6) crippling arthritis or painful foot conditions that restrict the individual’s ability to walk, 7) unstable heart conditions, and 8) diagnosis of blindness. Exclusion criteria will be determined from the pre-assessment questionnaire and verified by portions of the individual’s medical record. The portions of the record that will be examined include medical history and prescription record. Access to these records will occur only after the participant has given informed consent.

Screening Process: Activities that will occur during the screening process include: 1) explanation of the study and tool that will be used to measure functional balance, 2)
safety measures that will be implemented, 3) signing of the informed consent form, 4) assessment of cognitive status (this includes ability to follow a three-step command), using the Folstein mini-mental state examination, 5) assessment of the individual’s ability to walk a minimum of 40 feet, 6) completion of the pre-assessment questionnaire, and 7) assessment of functional independence using the Barthel Index. On all forms, the subject will be issued a code number to ensure that the patient’s identity is protected. If the subject meets the inclusion criteria for the study and is willing to participate, he/she will then be asked to sign up for a test session lasting no longer than 60 minutes.

**Testing Procedure:** The participants will be required to bring with them a pair of shoes and slippers. Definitions of these items will be addressed during the informational meeting. The testing will take place in a pre-determined section of carpeted hallway located in Michigan Christian Home. The participant will be asked to perform the activities listed on the Tinetti Balance and Mobility Assessment three times. It is necessary to perform the test three times so that the effect of shoe, slipper, and barefoot conditions can be assessed.

**Safety Measures:** The activities that are required of the participant consist of ordinary activities of daily living, and therefore present very little risk to the individual. However, to ensure subject safety, one researcher will walk alongside the participant during the testing procedure to protect against a fall. In the unlikely event of a medical emergency, the existing procedures outlined by the facility in which the testing is taking place will be implemented. The procedures will be reviewed by the researchers prior to the testing sessions.
APPENDIX D
INFORMED CONSENT FORM

I UNDERSTAND THAT the purpose of this study is to gather information regarding footwear and its relationship to functional balance. The results of this study will help the researchers determine the relationship between three footwear conditions (shoes, slippers, and barefoot) and functional balance, which may help health professionals find better ways to reduce the risk of falling for some elderly individuals. I have been selected for this study based on my age, residential status, ability, and willingness to participate. I also understand that I am one of 40 participants in this study.

I ALSO UNDERSTAND THAT:

1. I will participate in one test session at the facility in which I reside lasting not more than 60 minutes. I will also be given the opportunity to rest between trials, and whenever I request a break.
2. Prior to my admittance into this study, I will be asked several questions during an interview in regard to my problem-solving abilities, footwear preferences, history of falls, medical history, and functional capabilities.
3. Prior to my admittance into this study, I will be asked to walk forty (40) feet in a carpeted hallway to ensure that I am physically capable of participating in this study. I will be allowed to use any walking device (i.e. cane or walker) or brace that I am currently using.
4. Prior to my admittance into this study, portions of my medical record will be examined to verify my medical history and prescription record to ensure that I meet the qualifications of the study. I understand that this information is confidential and the researchers will protect my identity.
5. I will be asked to bring slippers that have soft soles, smooth bottoms, and no fasteners, and shoes that have hard rubber soles, low or no heels, and laces to the testing session.
6. I will be asked to perform activities in sitting and standing, as well as walk forty (40) feet in a carpeted hallway. I will be asked to perform each of these activities in the three different footwear conditions mentioned above. I will be allowed to use any walking device or brace that I am currently using.
7. These activities are not intended to cause falls or bodily harm, however, there is a slight chance of falling. As a precaution, one researcher will guard against falls while I am performing the activities.

8. I may withdraw from the screening or testing part of this study at any time.

9. I may ask questions of researchers, Kristen Brooks, Stacey Jonkman, or Matt Schmitz, or Grand Valley State University professor Paul Huizenga (616) 895-2472 (Chairman, Institutional Review Board) at any time.

10. I may obtain a summary of the results of this study on request.

I CONFIRM THAT:

1. I understand the purpose of this study and that my voluntary participation will enable the researchers to gain a better understanding of the relationship between footwear and functional balance.

2. The specific activities that I will perform have been explained to me by the researchers.

3. I have had an opportunity to ask questions about this study and they are answered to my satisfaction.

4. I know I may contact researchers Kristen Brooks at (616) 281-2284, Stacey Jonkman at (616) 281-2284, or Matt Schmitz at (616) 667-1005 if I decide not to participate and that there will be no consequences as a result.

5. I am willing to release the information obtained in this study to the scientific literature and that I will not be identified by name.

I HAVE READ AND UNDERSTOOD THE ABOVE INFORMATION AND AGREE TO PARTICIPATE IN THIS STUDY.

Participant’s Signature: ___________________________ Date________________

Witness’ Signature: ______________________________ Date________________
APPENDIX E
**Folstein Mini-Mental State Exam**

<table>
<thead>
<tr>
<th>Orientation: What is the year, season, date, day, or month?</th>
<th>Maximum Score</th>
<th>Score</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the year, season, date, day, or month?</td>
<td>5</td>
<td></td>
<td>Ask for the data. Then proceed to ask other parts of the question, one point for each correct segment of the question.</td>
</tr>
</tbody>
</table>

| Where are we: state, county, town, hospital, or floor? | 5 | | Ask for the facility then proceed to parts of the question, one point for each correct segment of the question. |

| Registration: Name three objects (bed, apple, shoe). Ask the patient to repeat them. | 3 | | Name the objects slowly, one second for each. Ask him to repeat. Score by the number he is able to recall. Take time here for him to learn the series of objects, up to 6 trials, to use later for the memory test. |

| Attention and Calculation: Count backwards by 7s Start with 100. Stop after 5 calculations. | 5 | | Score the total number correct (93, 86, 79, 72, 65) |

| Alternative question: Spell the word "world" Backwards. | 5 | | Score the number of letters in correct order: (diorw=5, diorw=3) |

| Recall: Ask for three objects used in question 2 to be repeated | 3 | | Score one point for each correct answer. (bed, apple, shoe) |

| Language: 1. Naming: name this object (watch or pencil) | 2 | | Hold the object. Ask patient to name it. Score one point for each correct answer. |

| 2. Repetition: Repeat the Following - "No ifs, ands or buts." | 1 | | Allow one trial only. Score one point for correct answer. |

| 3. Follow a 3-stage command: "Take this paper in your right hand, fold it in half, and put in on the floor." | 3 | | Use a blank sheet of paper. Score one point for each part correctly executed. |

| 4. Reading: Read and obey the following: Close your eyes. | 1 | | Instruction should be printed on a page. Allow patient to read it. Score by a correct response. |

| 5. Writing: Write a sentence. | 1 | | Provide paper and pencil. Allow patient to write any sentence. It must contain a noun, verb, and be sensible. |

| 6. Copying: copy this design | 1 | | All 10 angles must be present. Figures must intersect. Tremor and rotation are ignored. |

**Total Score**
Pre-Assessment Questionnaire

Name:________________________________________

Date of Birth:_______________ Age:_____________

Phone Number: ( ) _________________ Sex: □ Male □ Female

Name of facility in which you reside: ____________________________

Length of Residence: ________________

Number of falls in the past 12 months: _____

Number of injurious falls (requiring medical intervention) in the past 12 months: _____

Number of prescription medications: _____

Type of Footwear I most commonly wear:
□ shoes with laces or velcro □ slippers □ barefoot □ other ______

I currently use a walking aid, such as a cane or walker: □ yes □ no
Indicate type of walking aid: ___________________

I wear a brace or an orthotic on my leg or foot: □ yes □ no

PLEASE RESPOND TO EACH QUESTION BY CHECKING YES OR NO

1. I have had an amputation of the leg or foot. ............... □ yes □ no
2. I have been diagnosed with Parkinson’s Disease. ......... □ yes □ no
3. I have been treated for a stroke by a physician. ............ □ yes □ no
4. I have been treated for a traumatic head injury by a physician. .................................................. □ yes □ no
5. I have been diagnosed with Multiple Sclerosis or some other neurological disorder. ........................... □ yes □ no
6. I have been diagnosed with an inner ear disorder such as Meniere’s disease or Benign Paroxysmal Positional
Vertigo. .......................................................... □ yes □ no

7. I have crippling arthritis or a painful foot condition that restricts my ability to walk. ........................................... □ yes □ no

8. I have an unstable heart condition such as unstable angina, congestive heart failure, or preventricular contractions. .......................................................... □ yes □ no

9. I have been diagnosed as legally blind. ......................... □ yes □ no

---

To be filled out by the researchers:

- Medical records have been examined and are consistent with reports: □ yes □ no
- Subject is able to independently walk a minimum of 40 feet with or without the use of an assistive device or brace: □ yes □ no
- Subject demonstrates ability to follow a three-step command: □ yes □ no
- Level of care receiving: □ Home for the Aged □ Assisted living □ Health care Center
- Types of Co-morbid diagnoses: ____________________________________________________

________________________________________________________
Medical Records Confidentiality Statement

__________________________________________
Hospital/Clinical Facility places great importance in the confidentiality of medical records. Use of the medical records for research or learning experience is permitted, provided the researcher student realizes his/her role in responsibility in protecting the confidentiality of personally identifiable information. Misuse of information collected could result in personal liability and the implementation of punitive action.

I acknowledge that I have read the above statement and take the responsibility for proper and limited use of the confidential information in my research project or educational activity.

__________________________________________  __________________________
Signature                                              Date

__________________________________________  __________________________
Signature                                              Date

__________________________________________  __________________________
Signature                                              Date

__________________________________________
Research Project/Educational Activity

__________________________________________
Instructor’s Signature
Dear Administrator,

Thank you for allowing us to use your facility as a study site for our research. We would greatly appreciate it if you would take the time to complete the enclosed form. This is very important as it will enable us to report on the characteristics of the study site. Also enclosed you will find a stamped and addressed envelope for your convenience. Thank you for your timely response.

Sincerely,

Kristen Brooks          Stacey Jonkman          Matt Schmitz
STUDY SITE CHARACTERISTICS RESPONSE FORM

1. Total number of residents:

2. Description of different levels of care available to the residents:

3. Percentage of residents in each level of care:

4. Male/Female ratio:

5. Staff/resident ratio:

6. Age range of the residents:

7. Average age of the residents:

8. Percentage of Medicare, Medicaid, and private pay residents:

9. Social activities available to the residents:
10. Description of the type of floor surface, lighting, and wall coloring in the residents’ rooms:

11. Description of the type floor surface, lighting, and wall coloring in the hallways:

12. Description of the type of floor surface, lighting, and wall coloring in the residents’ bathrooms:
APPENDIX I
### Comprehensive Data Recording Sheets

<table>
<thead>
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<th>CODE</th>
<th>AGE</th>
<th># OF MEDS</th>
<th># OF FALLS</th>
<th># OF INJURY FALLS</th>
<th>ADJ. HEEL HT.</th>
<th>MMSE SCORE</th>
<th>ADJ. MMSE HEEL HT.</th>
<th>Score Barthel</th>
<th>Sole Surface</th>
<th>Shoe Type</th>
<th>Slipper Type (Sole)</th>
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<td>Barefoot</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>0</td>
<td>0</td>
<td>Shoes with laces</td>
<td>21 mos.</td>
<td>HFA</td>
<td>Barefoot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0</td>
<td>0</td>
<td>Slip-on</td>
<td>60 mos.</td>
<td>HFA</td>
<td>Nylons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Barthel Index

<table>
<thead>
<tr>
<th><strong>Self Index</strong></th>
<th>&quot;Can do by myself&quot;</th>
<th>&quot;Can do with help of someone else&quot;</th>
<th>&quot;Cannot do at all&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Drinking from a cup</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2. Eating</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. Dressing upper body</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>4. Dressing lower body</td>
<td>7</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5. Putting on brace or artificial limb</td>
<td>0</td>
<td>2</td>
<td>0 (not applicable)</td>
</tr>
<tr>
<td>6. Grooming</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7. Washing or bathing</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8. Controlling urination</td>
<td>10</td>
<td>5 (accidents)</td>
<td>0 (incontinent)</td>
</tr>
<tr>
<td>9. Controlling bowel movements</td>
<td>10</td>
<td>5 (accidents)</td>
<td>0 (incontinent)</td>
</tr>
</tbody>
</table>

### Mobility Index

<table>
<thead>
<tr>
<th><strong>Mobility Index</strong></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Getting in and out chair</td>
<td>15</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>11. Getting on and off toilet</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>12. Getting in and out of tub or shower</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13. Walking 50 yd. on the level</td>
<td>15</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>14. Walking up/down 1 flight of stairs (8)</td>
<td>10</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>15. If not walking: propelling or pushing wheelchair</td>
<td>0</td>
<td>0</td>
<td>0 (not applicable)</td>
</tr>
</tbody>
</table>

**Total Score:** ________