PREDICTING FALLS WITHIN THE ELDERLY COMMUNITY:

COMPARISON OF POSTURAL SWAY, REACTION TIME, THE BERG BALANCE SCALE AND THE ABC CONFIDENCE SCALE FOR COMPARING FALLERS AND NON-FALLERS

by
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Summary

Falls and fall related injuries present a serious challenge for both family members as well as health care professionals. The consequences from this trauma are quite significant resulting in a decrease of activities of daily living, fractures and in more serious cases, death. For these reasons, this subject matter deserves immediate attention. In the following manuscript, several intrinsic risk factors were evaluated between a population of geriatric fallers and non-fallers. The study allowed us to conclude that several risk factors were significant in the prediction of falls. In particular, fallers displayed slower reaction times and received higher mean scores on the Berg Balance Scale and the Activities-Specific Balance Confidence Scale. In turn, health care professionals could use these results in the successful identification of fallers and subsequently enroll these individuals in a fall prevention program as well as monitor their progress on a monthly or yearly basis.

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Foreword

This manuscript is part of the research I participated in during my master's studies at Laurentian University during the last two years. The scientific portion of my masters degree will be outlined in the following pages, however, I would like to take the opportunity to thank all the individuals whose contributions where greatly appreciated. First and foremost, I would like to thank my thesis director, Dr Yves Lajoie for his expertise, devotion and patience to this study. You always made me strive for excellence by constantly challenging my intellectual abilities. I valued the professional relationship we developed working together throughout the past four years. I now consider you to be more than a mentor and role model, but a good friend. Thanks again for everything.

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Table of Contents

List of Figures and Tables

CHAPTER I

GENERAL INTRODUCTION

Aging is an inevitable entity that will affect mankind at one point or another during one's lifetime. These changes affect the aging individual psychologically, socially and, more importantly, physiologically resulting in significant changes to relatively all of the major body systems. Of interest to this study, the three main systems that help to maintain one's balance, namely the visual, vestibular and somatosensory systems are seriously compromised. With this reduction in balance ability, the elderly individual is more prone to sustaining a fall or fall related injury.

Falls have been described as a multifactorial entity in the sense that more than one system is considered as a causal factor. Generally speaking, researchers have identified both intrinsic and extrinsic variables in association with falling. Even though environmental factors play a role in the cause of falls, intrinsic variables seem to be more indicative of falls within community-dwelling elderly subjects (Nickens, 1985).

The following study consists of evaluating the effect of specific intrinsic variables and their subsequent influence on the incidence rate of falls. This specific population has suffered from falls on at least one occasion as a result of intrinsic host variables. The information gathered with regards to the etiology of falls will most definitely be valuable in the prevention of future falls from occurring.

The review of literature (Chapter II) of this manuscript deals with specific physiological risk factors and their relationship on the occurrence of fall status. The first section outlines the incidence rate and subsequent effects of falls in a geriatric population. The second section illustrates demographic statistics in relation to aging in the United States and Canada. The third section describes the mechanical properties of balance and how they are comprised by the aging process. The fourth section outlines the various functional indicators measuring falls. The fifth section shows the more psychological indicators of falls and their relationship with fall status.

Chapter III of this manuscript consists of a research study destined for publication in a scientific journal concerned with gerontological studies. It consists of methodology related to the present study, followed by the results and discussion of the findings. The final chapter consists of general conclusions of the present study.

CHAPTER II

REVIEW OF LITERATURE

1.0 Incidence Rate and Effects of Falls in The Elderly Population

Falls present a substantial health problem among the elderly population. Approximately one third of community dwelling people over 65 years of age will experience one or more falls each year (Shumway-Cook et al., 1997; Tinetti et al., 1988; Powell & Myers, 1995; Stelmach & Worringham, 1985; Spirduso, 1995; Hausdorff et al., 1997). Subsequently, the frequency increases to nearly 40% for those individuals over 80 years of age (Powell & Myers, 1995) and affects women more than men (Nickens, 1985). In particular, Sheldon (1963) found that 24% of males and 44% of females aged 65 years and older had a history of falling. It is also interesting to note that men who fall, have higher mortality rates when compared to women within the same category (Ochs et al., 1985).

Fall related injuries are the leading cause of non-fatal injury. Nearly 40% of falls occurring in the 65 and over population are admitted to the hospital for some type of treatment (Tideiksaar, 1988; Shumway-Cook et al., 1997). In 15% of the cases, the injuries suffered include fractures, bruises, soft tissue injuries and loss of dependence (Powell & Myers, 1995). Serious injury occurs in 6% of the elderly population (Spirduso, 1995) resulting, in some instances, in accidental death (Baker et al., 1984). A study conducted by Alexander et al., (1992) found that the hospitalization rate for falls was fivefold the rate of any other trauma for individuals 65 years of age and older. In fact, it was found that approximately 6% of the initial $995,499,233 cost for hospital care in the 65 year and older population was due to fall related injuries. Approximately 40 to 50% of fallers admitted to hospitals will be admitted to nursing homes (Tinetti et al., 1988; Shumway-Cook et al., 1997). Of those who did not suffer serious injury, many may experience significant restrictions in daily activities (Tinetti et al., 1988). As a result, the elderly population develop a fear of falling complex (Maki et al., 1991), a decrease in self confidence to accomplish normal activities of daily living and adopt a lifestyle of inactivity resulting in significant muscular atrophy, most noticeable in lower extremity strength (Tinetti, 1987; Wolfson et al, 1995).

2.0 Demography of Aging

This serious health problem deserves immediate attention due to the fact that human life expectancy has continually been increasing throughout history. In fact, it is in the present century that this increase has shown a dramatic acceleration. In the United States, life expectancy has increased some 26 years from 1900 to1990 with women living approximately 6 years longer than the average male (Timiras, 1994). In large part, longer life expectancy could be due to medical advances as well as major improvements in living habits, socioeconomic status and sanitation conditions. It is not surprising that people are living longer, "but the aged also represent the most rapidly growing segment of the population in developed countries" (Timiras, 1994, p.7).

Canadian demographic statistics have shown several similarities when compared to the life expectancy rates in the United States. In Canada, individuals 65 years and older represented approximately 12% of the population in 1996, and this percentage is expected to increase to nearly 16% by the year 2016. (Statistics Canada, 1996). This "graying" effect is also reflective in the population who are aged 75 years and older (Timiras, 1994). This group also represents a fast growing portion of the total population increasing to an estimated 7 percent by the year 2016 (Statistics, Canada, 1996).

The increases in both number and proportion of the elderly population will have important influences on several aspects of society. As a group, the elderly will spend considerable amounts of money, voice more political power and require more services. Therefore, it is essential to understand these age-related changes if society is to adjust positively to this phenomenon (Digiovanna, 1994). In turn, health care professionals must address several problems occurring within this particular population. One of the most important and common problems is related to falls (Baker et al., 1984).

3.0 Mechanical Properties of Balance and Falls

Many studies have focused on the possible risk factors associated with falling in the elderly population. (Robbins et al., 1989; Campbell et al., 1989; Tinetti et al., 1988; O'Loughlin et al., 1993; Myers et al., 1996; Nickens, 1985). Typically, these risk factors are categorized into two distinct groups: intrinsic and extrinsic. Intrinsic factors consist of those factors related to the physiological changes associated with aging whereas extrinsic or environmental factors are a direct result of one's environment such as improper footwear and unstable living conditions (Tideiksaar, 1997). Seeing that a large proportion of falls are comprised of more than one likely cause, Rigler (1999) postulates that clinical assessments of falls should include both intrinsic and extrinsic factors as it is believed that they have a close interaction on the incidence rate of falls. This will ensure that health care professionals cover a wider range of etiological pathologies in identifying the likely cause of each patient's fall history. As a result, physiotherapists, nurses and medical doctors will be able to implement specific intervention strategies in preventing future falls.

3.1 Extrinsic Risk Factors

Extrinsic factors have been found to have a profound impact on the incidence rate of falls in the elderly population. In fact, several researchers have found that they account for as much as 30 to 50% of falls suffered by the elderly (Hornbrook et al., 1994). These results are consistent with the work of Hale et al., (1992) whom believe that these environmental factors can account for up to 55% of falls. Urton (1991) has identified five etiological factors related to environmental hazards. These settings are commonly identified as the bathroom, the bedroom, stairways, the dining room as well as the kitchen. These factors are consistent with the findings of Campbell et al., (1990) in which they found that falls were more likely to occur in the rooms that the residents utilized most often. It is worth noting that 21.4% of falls occurred in the bathroom, 19.1% occurred in the kitchen area, whereas 27.4% occurred in the dining room. With respect to those individuals residing in nursing homes or senior residences, 64% of falls occurred in the resident's bedroom and 18.4% occurred in hallways or passageways.

3.11 Modification of Home Hazards in Preventing Falls

With a large proportion of falls occurring in the home setting, home inspection programs have been developed in the hope of reducing falls and fall related injuries. Cumming et al., (1999) suggests that home assessments be conducted by occupational therapists as this will prove to be much more effective in the long run, as opposed to providing hazard checklists to the elderly homeowners. The researchers firmly believe that the occupational therapists will be able to readily identify all potential hazards as this is their primary area of expertise. Through the early identification and modification of these hazards, health care professionals can significantly reduce the likelihood of tripping over these obstacles and, in turn, reduce the rate of falls and fall related injuries in the elderly population.

3.2 Intrinsic Risk Factors

Intrinsic risk factors of falls are caused primarily by those physiological factors or systems affected due to the aging process. These systems play an important role in the integration of relevant spatial information needed to maintain balance and upright posture. These factors have been identified as medication use (Blake et al., 1988; Spirduso, 1995), loss of balance (Overstall et al., 1977), syncope (Tinetti et al., 1988), postural instability (Overstall et al., 1977; Okuzumi et al., 1996); visual impairment (Okuzumi et al,, 1996), neurological disabilities (Morris et al., 1987) muscle weakness (Whipple et al., 1987; Shumway-Cook et al., 1997) as well as sensorimotor deficiencies (Stelmach & Worringham, 1985). Work by Tinetti et al., (1988) has focused on the impact of these variables and their subsequent relationship with falling in the elderly population. The results showed that the likelihood of falling increased in a linear fashion with regards to the amount of risk factors. The risk of falling increased from 8% when none of the risk factors were present to approximately 80% when 4 or more risk factors were present. This is further supported by Blake et al., (1988). Nevertheless, several researcher's seem to believe that even though extrinsic and intrinsic variables have a somewhat combined effect on falling, the latter would be more likely to have occurred as a result of intrinsic factors due to the physiological changes that occur as one ages (Nickens, 1985; Spirduso, 1995; Morfitt, 1983).

3.21 Balance

Balance or equilibrium is defined as the ability to maintain one's center of gravity within the functional base of support. Equilibrium is maintained primarily by two different types of balance systems. Static balance is the ability to maintain an upright stance position during quiet unperturbed conditions (Spirduso, 1995). This task is accomplished by the saccule and utricle, anatomical structures located within the inner ear (Marieb, 1993). On the other hand, dynamic balance is the ability to maintain upright stance under abnormal or perturbed conditions where subjects must recruit the appropriate muscle groups in order to avoid falling (Spirduso, 1995). In this case, the semicircular canals are responsible in the maintenance of this particular type of balance (Marieb, 1993). The balance system of the human body is a rather complicated one in that several sensory systems interact together allowing individuals to maintain equilibrium. In the following section, we will briefly discuss each one of the systems and their relative importance in maintaining balance stability.

3.22 The Visual System

The visual system is one of the most elaborate receptors the human body relies upon in order to provide information regarding one's spatial environment (Marieb, 1993). Generally speaking, the visual system is organized into two distinct entities, each independent of the other. The peripheral visual field is responsible for the determination of "where" one's body is in relation to their spatial environment. On the other hand, the foveal, or central visual field is responsible for recognizing and identifying "what" we are looking at.

The contribution of the visual system on maintaining balance has been the focus of several research studies. In particular, Woollacott et al., (1988) examined dynamic balance ability in young and elderly cohort groups under various visual conditions (peripheral vs. central). The results from the study showed that the elderly experimental group relied primarily on information provided from the peripheral visual field. Also affected is the ability to distinguish between various colors as well as decreased abilities in making the transition between light to dark visual occurrences (Lord et al., 1991).

3.221 Visual Acuity

Research trends have shown that visual acuity is significantly affected due to the aging process. Lord et al., (1991) reported that it can be reduced as much as 80% in those individual over 90 years of age. In fact, they found that "multiple fallers had reduced vision, decreased peripheral sensation, slower reaction times and decreased stability compared with non-multiple fallers" (Lord et al., 1991, p. 1198). This visual impairment, in turn, affects contrast sensitivity, which is referred to as the ability to distinguish contrasts or the shapes of objects as they appear in one's spatial environment (Steinweg, 1997). Owen (1985), believes that this particular type of visual impairment is significantly associated with an increased rate of tripping in the elderly.

Even though significant associations between the visual system and falls have been found to exist, other research findings seem to indicate contradictory results (Lord et al., 1991). Findings by Brocklehurst et al., (1982) elicited no interaction between visual acuity and the likelihood of suffering a fall in elderly individuals between the ages of 65-

74, 75-84 and the 85 years of age and older subjects (Brocklehurst et al., 1982 as cited in Lord et al., 1991). This is in accord with published findings by Campbell et al., (1989) whom were unable to find any positive interaction between predicting falls and visual acuity. In light of this evidence, it is essential that further research in this area be conducted in order to determine the effect visual acuity plays in predicting future falls.

3.23 The Vestibular System

The vestibular system is an important contributor to dynamic balance (Pozzo et al., 1991) in that it relays information about the various movements of the head (Spirduso, 1995). Physiologically speaking, the vestibular system is comprised of two structural units, the otoliths and the semi-circular canals. These structures respond to changes of body position and gravity, stimulating impulses produced by the hair cells in order to maintain balance and equilibrium (Marieb, 1993).

Deterioration of this system as a result of the aging process has been noted to occur as early as 40 years of age (Spirduso, 1995). According to Rosenhall & Rubin, (1975), those individuals over 70 years of age can lose up to 40% of vestibular function. Assessments of this system have been aimed at monitoring postural sway. Research in this area has overwhelmingly shown that elderly individuals sway at a higher rate when compared to younger subjects (Okuzumi et al., 1996; Maki et al., 1991). Keeping in mind that all three systems interact together as an entity in maintaining balance, it is somewhat difficult to determine which of the three systems is the more affected in balance deficiencies.

3.24 The Somatosensory System

The somatosensory system is the third component that is responsible for the maintenance of balance and upright stance. This important system is composed of many sensory receptors responsible for touch, pressure, vibration as well as the many muscle receptors found throughout the human body (Marieb, 1993). The sensory receptors provide important information with respect to limb and body location (Spirduso, 1995).

Research has suggested the occurrence of a gradual loss of sensitivity of these particular receptors as one ages (Whanger & Wang, 1974). In fact, studies have focussed on the vibratory mechanisms of the lower limbs as it has been suggested that the ability to sense vibration dramatically affects upright stance during posture evaluation (Brocklehurst et al., 1982). Even though significant changes have been confirmed to occur in the aged vestibular, visual and somatosensory systems, the underlying principle seems to suggest a cumulative effect of all three systems rather than of only one of the aforementioned systems.

3.30 Intrinsic Versus Environmental Risk Factors in Predicting Falls

As previously mentioned, many authors have generally classified fall causation as either intrinsic or extrinsic in nature. This overwhelming body of literature has shifted somewhat in that the new belief regarding the etiology of falls is presumed to be caused by intrinsic factors affecting the physiological body systems of the aged (Nickens, 1985). Evidence suggests that postural instability, balance deficiencies, vertigo and blackouts all increase fall risk dramatically as an individual ages (Overstall et al., 1977). This is supported by Fernie and colleagues whom found that the speed frequency in which one sways during upright stance is much faster for those with a previous history of falling

(Fernie et al., 1982). A specific study conducted by Morfitt (1983) examined the difference between intrinsic and extrinsic variables in predicting the opportunity of suffering a fall. The results are consistent with the work of Overstall et al., (1977). Morfitt (1983) found a cutoff age of 75 allowing to distinguish between intrinsic and extrinsic factors responsible for falls. This seems to suggest that falls occurring to those below 75 years of age were more likely caused by environmental factors whereas falls occurring to those aged over 75 years of age were caused primarily by intrinsic risk factors. These results were representative of the female subjects only inferring that results could not be extrapolated to a male population. In light of this evidence, it seems rather evident to study the more intrinsic risk factors and determine how they are linked to falls in the elderly population.

4.0 Predicting Falls within a Geriatric Population

4.1 Balance as an Indicator of Predicting the Occurrence of Falls

Balance has been shown to be an important predictor of falls within the elderly population (Berg et al., 1992). It is a component that is needed to accomplish a wide variety of daily living activities such as gardening, reaching for items in a cupboard as well as walking. Recently, researcher's have found that balance can be altered by factors such as medication use (Blake et al., 1988; Spirduso, 1995), neurological disorders (Morris et al., 1987) or even due to the normal physiological changes associated with aging (Berg et al., 1992). Throughout the years, several instruments have been developed as a means of quantitatively measuring balance in the elderly population. These screening tools have been instrumental in evaluating the ability to maintain balance and subsequently, in the identification of those individuals who present a substantial risk of falling in the very near future. The following discussion is a brief description of the various balance instruments used in distinguishing between a healthy and frail geriatric population.

4.11 The Berg Balance Scale

The Berg Balance Scale was developed by Berg et al., (1989) as a means of assessing one's ability to perform a variety of balance specific activities of daily living (ADL's) (refer to Appendix 1). Subject's are evaluated on a 5 point system, (0-4). The scores indicate the individual's ability to maintain stable posture and balance throughout each activity. A score of 0 yields the inability to perform the task at hand whereas a score of 4 indicates near perfect ability to maintain balance and upright posture during the ADL's. The scores for each item are then added together and the score is ranked out of 56 (perfect score for successfully completing all of the 14 items in the balance scale).

4.12 Balance in the Elderly Patient: The Get-Up and Go Test

This particular test measures balance mobility in an elderly cohort in order to monitor the incidence rate of falls. Subjects are required to rise from a chair (with an armrest and a seat height of approximately 46 cm), walk 3 meters, turn 180 degrees, return to the arm chair and sit down. The activity is ranked on a five point scoring system (1-5) (Mathias & Nayak, 1986).

4.13 The Timed Up & Go Test: Test of Basic Functional Mobility for Elderly Persons

Podsiadlo & Richardson (1991) argued that the scoring system was not very accurate in explaining the balance performance between observers. They found that, even though the extremes of the scale were relatively clear and easy to identify, the middle scores were ambiguous and rather difficult to score. For this reason, they proposed a similar model to the "Get-Up and Go Test" proposed by Mathias & Nayak, (1986). Subjects are required to complete the same task as in the "Get-Up and Go Test" with the sole difference being that the trials are timed allowing for more reliability and validity.

4.14 Functional Reach: A New Clinical Measure of Balance

This particular balance scale was developed by Duncan et al., (1990) with the underlying purpose of measuring dynamic balance as subject's perform functional reach trials. In this study, functional reach was defined as the furthest distance one can reach in the forward direction in a 90 degree shoulder flexion starting point all the while subject's maintained a fixed standing position on a force platform. The force platform allowed the researcher to measure the center of pressure excursion (COPE) in relation to their base of support. Reaching distance was quantitatively measured by means of a "48 inch yardstick".

4.15 The Influence of Sensory Interaction on Balance

This instrument was developed as a means of assessing the sensory modalities and their interaction with postural sway during standing conditions. Subjects are required to complete 6 different experimental conditions upon which, the sensory modalities are modified during each condition. In particular, the conditions alter visual feedback mechanisms as well as the support surface on which the subject's are tested on. Results are analyzed by means of three different reporting systems. Postural sway is observed for a 30 second time period and the results are recorded by an ordinal ranking scale with a stopwatch in order to determine the duration subject's are able to maintain an upright standing position by means of a plumb line. This will allow the researcher to monitor body displacement during the experimental conditions (Shumway-Cook & Horak, 1986).

4.16 Performance Oriented Assessment of Mobility Problems in Elderly Patients

This instrument, as developed by Tinetti (1986), consists of a 13-item performance oriented mobility scale measuring various activities of daily living. Each item is graded as either normal, adaptive or abnormal abilities in completing the task at hand. In addition, a 9-item performance based balance and gait assessment is included for this balance evaluation tool. These balance and gait parameters are categorized as either normal or abnormal findings.

4.17 Balance Instruments: Determining the Best Predictor for Falls in a Geriatric Population.

A recent study by Whitney et al., (1998) reviewed a number of balance instruments that have been developed throughout the years as a means of identifying those individuals who present a high risk of falling in a geriatric cohort. Of interest to the present study, six balance instruments were evaluated in terms of validity, reliability, equipment needed to evaluate balance performance, the length in which it takes to administer the test, the advantages and disadvantages of each instrument as well as the specific target population it was designed for. The six balance instruments evaluated in the study were the Berg Balance Scale (Berg et al., 1989), the Clinical Test of Sensory Interaction and Balance (Shumway-Cook & Horak, 1986), the Functional Reach Test (Duncan et al., 1990), the Tinetti Balance Test of the Performance Oriented Assessment of Mobility Problems (Tinetti, 1986), the Timed "Up & Go" Test (Podsiadlo & Richardson, 1991) and the Physical Performance Test (Reuben & Siu, 1990).

In terms of administration time, results showed that all six instruments could be completed in a very short and reasonable time frame. The fastest instrument was found to be the Functional Reach Test with an administration time of 1 to 2 minutes whereas the longest was found to be the Berg Balance Scale with a total time of 15 minutes.

With respect to the equipment needed for each balance instrument, it was found that Podsiadlo and Richardson's Timed "Up & Go" test required the least amount of tools whereas the Berg Balance Scale and the Physical Performance Test required the most. The tools required to perform the Berg Balance Scale consisted of two chairs (one with an armrest and one without), a stop watch, a ruler and a foot stool, items that are commonly found in a household or clinical setting.

It was found that the six balance instruments displayed respectable interrater reliability while the Berg, the Physical Performance and the Timed "Up & Go" demonstrated reasonable intrarater reliability. With respect to predictive validity, it was determined the Functional Reach Test, the Tinetti Balance Scale and the Berg Balance Scale all have the ability to establish this parameter. Construct validity was applicable for three of the six instruments, namely the Clinical Test of Sensory Interaction and Balance, the Functional Reach Test and the Berg Balance Scale.

Each instrument has certain advantages and disadvantages in terms of assessing balance performance. The Functional Reach Test was rather easy to administer and very precise in measuring balance abilities. The only drawback rests on the fact that the measurement is obtained only in the forward direction. The Tinetti Balance Scale was also easy to administer, provided measures for multiple factors of balance performance however, it lacks sensitivity with respect to variations in the various aspects of balance. The Berg Balance Scale measures multiple aspects of balance but requires the most time to administer. The Clinical Test of Sensory Interaction and Balance is also relatively easy to administer however it lacks the ability to evaluate all components of balance other than the sensory component. The Physical Performance Test is fairly easy to score and administer but it is the balance instrument that requires the most equipment. Lastly, the Timed "Up & Go" requires very little equipment, takes very little time to complete but does not measure all aspects of balance. It was also found that the target population for each individual balance instrument is aimed towards a geriatric population aged 65 years of age and older.

The determination of the appropriate balance instrument will depend primarily on the specific aspect of balance that is being tested. It has been postulated that since balance consists of several systems interacting at one time, more than one balance instrument may be required to effectively predict falling. On a similar note, a study conducted by Berg et al., (1992) evaluated the effectiveness of these various tests in measuring balance in an elderly population. Results showed that the Timed up and go test as well as the Berg Balance Scale provided the most efficient balance measures and that the Berg Scale provided the best overall scores on balance performance.

This is further supported by Shumway-Cook et al., (1997). This study looked at eleven possible risk factors and their association with falling. In particular, age, gender, medications, mental status, the use of assistive devices, the Berg Balance Scale, the dynamic gait index, balance self-perceptions test, self-paced gait, fast-paced gait and history of imbalance were studied in relation to falls. The results showed only five of the eleven variables, namely the Berg Balance Scale, use of assistive devices, the dynamic gait index, the balance self-perceptions test and history of imbalance were identified as significant risk factors in predicting the likelihood of falls. It was shown that the Berg Balance Scale was the single best predictor of falls. Moreover, it was determined that a cutoff score of 49 out of a possible 56 provided sensitivity values of 77% and specificity values of 86%. This implies that a one-point decrease in balance scores results in a 6 to 8% increase in fall risk. This percentage increases to 100% when a score below 36 is obtained. It seems rather evident that the Berg Balance Scale is one of the better instruments used to assess balance abilities in the elderly population due to the fact that it measures the more dynamic components of balance, activities that are encountered on a daily basis. In addition, it encompasses activities similar to the other balance instruments such as Functional Reach. Indeed, this makes the Berg Balance Scale much more versatile than the other functional markers of balance.

4.2 Cutoff Scores In Predicting The Incidence Rate Of Falls

Even though the Berg Balance Scale seems to be a very important predictor for falls, there is variability with regards to the cutoff scores as determined by logistic regression analysis. As previously mentioned, Shumway-Cook et al., (1997) found that a cutoff score of 49 was effective in predicting fallers. However, in a similar study, Berg et al., (1992) discovered that a cut-off score of 45 was statistically significant and subsequently successful in distinguishing between healthy ambulatory seniors and frail individuals that require adequate monitoring and supervision. Nonetheless, it is rather evident that there exists large discrepancies with regards to these values. As a result, more research within this particular area is warranted in order to establish some type of gold standard with the underlying purpose of identifying one cutoff point that can and will effectively distinguish healthy elderly from those who present a serious risk of falling.

4.3 Sensorimotor Performance and the Aging Process

As one ages towards senility, the neuromuscular system undergoes various changes influencing motor and cognitive abilities. One of the most noticeable changes is the increased time required to react to environmental stimuli as well as choosing the proper voluntary movement associated to this delayed reaction (Stelmach & Worringham, 1985). Several researchers have studied the effect of reaction time, or more specifically, sensorimotor performance and the aging process. Reaction time is defined as the length of time measured between the presentation of an unexpected stimulus and the onset of a response to that stimulus (Schmidt, 1993). Research within this area has shown that reaction time responses seem to increase as one ages (Clarkson, 1978;

Gottsdanker, 1982; Loveless, 1980; Pierson & Montoye, 1958). Throughout the years, many theories have been developed in the hope of tentatively explaining this age-related decrease in responses or reaction times. More recently, Myerson et al., (1990) proposed a new model, *the information loss model*, that is more in agreement with the tentative explanation of the noticeable age-related changes in reaction time. Based on the foundation of this model, they believe that both young and old subjects alike, process and respond to external stimuli in a sequential order of steps, with each step lasting a precise amount of time. Myerson and colleagues stipulate that the subsequent duration of each step depends primarily on the inverse relationship of the information available in the subject's environment. This would suggest that if very little information were available to the subject, the amount of time to process through each step would increase, whereas if more information were available the process would be significantly shorter. It is hypothesized that normal aging has a profound effect on information processing (Haywood, 1993). As a result, older adults ultimately spend more time during each step when compared to younger subjects. This increase is even more noticeable when tasks become more attention demanding (Stelmach & Worringham, 1985; Jordan, & Rabbitt, 1977). When you couple these results with the notion that postural sway also increases with age, the combination effect can lead to an increased likelihood of falls. If an older individual presents a very unstable posture, and does not choose the appropriate response in a timely manner, he will exceed the point where balance recovery is no longer an option and hence, must prepare himself for a fall (Stelmach & Worringham, 1985).

4.4 Sensorimotor Responses and Falling

Presently within the literature, several studies have examined the relationship between simple reaction time and the incidence rate of falls. Tideiksaar stipulates that seniors are more apprehensive to an unfamiliar situation. This results in an increased time span when the elderly individual first perceives the stimulus to when an appropriate answer is delivered. In fact, Lord et al., (1999) found that elderly subjects with slower reaction times would be less likely to prepare themselves for the fall, running a higher risk of fracturing a hip. This increase is not likely due to the slowing of neural conduction but rather due to limitations in the processing of information as outlined in the previous section (Haywood, 1993). The majority of the studies examining reaction time and falling failed to create cutoff scores with regards to reaction times that would significantly differentiate between healthy elderly subjects and those who have a history of falling. It would be very interesting to produce such data, as it would provide a valuable tool to health care professionals as a way of monitoring patient's results with the hope of identifying future fallers.

4.5 Posture

The ability to maintain upright posture is accomplished by aligning the various body segments one in relation to the other. This process, as with balance, is also described in both static and dynamic entities. However, particular to posture, it is noticed that small body movements occur. This "swaying" is a type of corrective measure that is referred to as postural oscillation and allows an individual to recruit the appropriate muscle groups needed in order to remain standing.

Many studies have focussed on the effect of postural instability within the elderly population and it's subsequent association with falling. Three common magnitudes of sway have been cited throughout the literature and consist of lateral, anterior-posterior and total sway. It has been well documented that the relative variance of sway, measured by means of a force platform, increases as one ages (Eckert, 1988; Sheldon, 1963; Overstall et al., 1977; Maki et al., 1991; Okuzumi et al., 1996). In particular, Okuzumi, et al., (1996) found that the magnitude of total sway for elderly subjects increased significantly. Moreover, the magnitude of lateral sway was found be to significantly affected by age whereas the magnitude of anterior-posterior sway showed no substantial increase as a result of aging. This would suggest that older subjects have more difficulty controlling lateral than anterior-posterior sway. Other researchers, namely Buchner & Larson (1987) have found that the study of postural sway was indeed not a substantial predictor for balance ability and falls in an elderly population. Interestingly, Teasdale et al., (1993) found that the more an individual displays eccentric sway patterns, the longer it takes to respond to the reaction time stimulus. With this in mind, by combining simple reaction time and postural sway, a more efficient fall predictor variable can be identified which will help identify those at risk of falling.

4.51 Postural Sway and Attentional Demands

It has been documented that the ability to maintain a postural position or task involves additional attentional requirements (Marsh & Geel, 2000; Shumway-Cook & Woollacott, 1999; Lajoie et al., 1993; Lajoie et al., 1996). In fact, the attentional demands are subsequently increased in relation to the complexity of the task at hand.

This notion is well supported by Lajoie et al., (1993). In this particular study, it was found that dynamic balance or, more specifically, the ability to maintain an upright standing position is substantially more attention demanding when compared to static equilibrium. It was further demonstrated that reaction times measured during these various attention demanding tasks illustrated higher measures in a broad support stance phase as opposed to a sitting position in young adults. In a follow-up study by Lajoie et al., (1996), they found that healthy elderly subjects displayed significantly slower reaction times in a narrow base of support standing position when compared to the younger experimental group. These results would imply that additional attentional resources are required by the elderly population in order to maintain balance or an upright posture. It would be interesting to investigate if any significant differences would arise in a geriatric population who have a previous history of falling and those individuals whom have not experienced a fall.

5.0 Other Factors Affecting Balance Ability in the Aged

5.1 Neurological Pathologies: Increased Risk Factor for Falling?

It has been well documented that cognitive impairment has been linked with an increased rate of falls within the elderly (Droller, 1995; Morris et al., 1987; Okuzumi, 1997; Isaacs, 1978). In a study conducted by Morris et al., (1987), they examined the effect of Alzheimer's disease and it's relationship on falling. They found that from a logistic model incorporating medication, neurological signs, systolic and diastolic blood pressure, only the presence of dementia of the Alzheimer's type was the single significant predictor for falls. In fact, it was noted that the incidence rate of falls was three times more likely to occur to individuals suffering from Alzheimer's disease when compared to the healthy elderly. They also found that the demented subjects presented similar characteristics to the control fallers in the study. They were predominately female and had no significant differences with regards to blood pressure, medications, sensorimotor abilities, gait and posture. It was also found that dementia was indeed a crucial risk factor for falls when considered as a single entity.

On a similar note, a study conducted by Franssen et al., (1999) examined equilibrium and specific limb coordination in subject's suffering from dementia of the Alzheimer's type. After adjusting for age, it was found that those individuals who suffered from mild dementia scored significantly lower on equilibrium and limb coordination performance tests when compared to their healthy counterparts. These results would seem to imply that such measures could, most definitely, be used in assessing those individuals suffering from dementia and whom present a high incidence rate of falling. If this instrument proves accurate in doing so, health care professionals will be able to effectively identify those who have a high risk of falling and enroll them in a fall prevention program consisting of a gradual implementation of balance training exercises.

This is further supported by Okuzumi, (1997). In this particular study, postural control and locomotion was evaluated in patients suffering from vascular dementia and Alzheimer's disease. It was found that both types of dementias were associated with noticeable declines with respect to body sway and walking velocity. In particular, it was determined that demented patients had significantly slower walking patterns and displayed more eccentric body sway patterns when compared to the normal healthy control group.

It is rather evident that the results from the present studies seem to converge on a general consensus that patients suffering from dementia of the Alzheimer's type have predisposing factors that make them more vulnerable to falls when compared to non-fallers. It is for this reason, that it is important to screen fall subjects prior to testing. This will ensure that the sample population will be free from any type of cognitive impairment that could affect their balance performance during the testing sessions and will provide accurate data allowing researchers to generalize their findings to the general geriatric population.

5.2 Fear of Falling

Aside from the more prevalent physiological factors linked to falling in the elderly population, research trends seem to have shifted their focus towards the psychological factors linked to falls (Wild et al., 1985; Wild et al., 1981). These factors are commonly referred to as "loss of confidence" in performing ADL's or the "fear of falling" syndrome. Interestingly enough, this fear of falling has been observed in healthy subjects as well as those individuals who have a previous fall history (Silverton & Tideiksaar, 1989). This syndrome has resulted in significant reductions of daily activities resulting in loss of independence. Vellas et al., (1987) studied the effects of falls on the restriction of daily activities. They found that subjects demonstrated a loss of independence with respect to three important factors. Firstly, subjects has an increased rate of fear of falling leading to restrictions in activities resulting in boredom and eventually, depression. Secondly, subjects demonstrated significantly less mobility and lastly, they walked with altered gait patterns.

5.21 Loss of Mobility

It has been well documented that falls generally result in loss of independence and inevitable declines in functional ability required to perform activities of daily living (Dunn et al., 1992; Maki, 1997; Maki et al., 1991; Kiel et al., 1991). These restrictions result in significant decreases in muscle tone and subsequent muscle atrophy (Vellas et al., 1987). Gehlsen et al., (1990) examined lower limb strength in an elderly cohort population by means of an isokinetic Cybex machine. It was found that lower limb strength for the ankle, knee and hip joints were significantly stronger in healthy men and women with no history of falls when compared to those with a prior history of falling. These results are in accord with the findings of Wolfson et al., (1995). In this particular study, nursing home residents had significantly weaker lower limb strength than their non-falling counterparts within the same nursing home. It was noted that strength differences were more noticeable at the ankle joint where subjects with a fall history demonstrated one tenth of tibialis anterior strength when compared to the control group. It seems rather evident that lower-limb muscle weakness is a very important indicator of balance and interventions should be geared towards strength training in these particular muscle groups (Wolfson et al., 1995; Tinetti, 1987; Shumway-Cook et al., 1997; Province et al., 1995, Gabell, 1986).

5.22 Gait Characteristics Associated to the "Fear of Falling" Syndrome

It has been shown that those individuals suffering from this particular syndrome have altered their gait patterns in accordance to the fear of sustaining a fall. Maki (1997), has studied the changing gait parameters as a result of the aging process. The results from the study seem to suggest that some gait parameters, namely shorter stride length, slower walking velocity as well as increases in the duration of the double support walking phase were successful in identifying "fear of falling" whereas stride-to-stride variability was more indicative of predicting the likelihood of future falls. Gelhsen et al. (1990) found differing results in that those subjects with a fall history adopted a much wider base of support (distance measured between heels) than the control group. This would seem to imply a conscious awareness of balance instability resulting in a compensation mechanism during upright stance and during walking trials for those individual who have previously fallen. It is rather obvious that the study of "fear of falling" is of great importance as it dramatically reduces one's activities of daily living subsequently leading to physical inactivity and an increased likelihood of falling. Safety strategies and interventions should be implemented as a means of identifying the individuals at risk in order to successfully reduce the incidence rate of falls before they occur.

5.3 Psychological Instruments Used in the Measurement of Balance Confidence and "Fear of Falling"

Generally speaking, the "fear of falling" syndrome has been measured as a dichotomous variable on a Yes/No scale of measurement. Within the past decade, two psychological tools have been developed with the hope of providing a more reliable way of monitoring and measuring balance confidence, loss of independence and "fear of falling". In the following section, these particular instruments will be described briefly. A review will then be presented to determine which one provides the best overall measurement outcomes of the psychological indicators for fall status.

5.31 Tinetti's Falls Efficacy Scale (FES)

This particular measurement scale was developed primarily to assess "fear of falling". The FES score is based on the following operational definition: "low perceived self-efficacy at avoiding falls during essential, non-hazardous activities of daily living" (Tinetti, 1990, p.240). The instrument is a fairly reliable one with a test-retest reliability of .71. Overall, this scale offers both a reliable and valid means of measuring fear of falling in the elderly (Tinetti, 1990).

5.32 The Activities-Specific Balance Confidence (ABC) Scale

The ABC scale was developed by 15 clinicians and 12 senior out-patients with the purpose of evaluating balance confidence. This 16-item scale is based on a replication of the FES scale (refer to Appendix 2). However, it differs from the FES in that it provides more activities of daily living that are considered more hazardous with a higher degree of difficulty. Powell and Myers (1995) believe that this psychological tool will be more effective in measuring balance confidence due to the fact that it measures activities on a more functional basis. As a result, this instrument could indeed be utilized in assessing senior citizens with various functional levels.

5.33 The ABC Scale and FES Scale: How to Determine the Best Outcome Measure for Balance Confidence

Both psychological instruments are good indicators of the "fear of falling" syndrome. Recent research has evaluated the reliability and validity of both tools. Powell & Myers (1995) found that the ABC scale was statistically more reliable ($r = .92$)

than the FES scale (r = .71) over a two week interval. In addition, the ABC scale had a higher internal consistency. It was also found that even though both instruments were effective in discriminating between different mobility groups, the ABC was that much more effective with respect to the effect size. It has been suggested that the scores of these psychological instruments be correlated directly to various activities of daily living. It is our goal to assess the "fear of falling" syndrome in the present study by means of the ABC scale. By combining the results from this psychological measure and the results from the Berg Balance Scale, we will indeed be able to effectively correlate both measures and determine their relationship with fall status.

CHAPTER III

PREDICTING FALLS WITHIN THE ELDERLY COMMUNITY: COMPARISON OF POSTURAL SWAY, REACTION TIME, THE BERG BALANCE SCALE AND THE ABC CONFIDENCE SCALE FOR COMPARING FALLERS AND NON-FALLERS

PREDICTING FALLS WITHIN THE ELDERLY COMMUNITY: COMPARISON OF POSTURAL SWAY, REACTION TIME, THE BERG BALANCE SCALE AND THE ABC CONFIDENCE SCALE FOR COMPARING FALLERS AND NON-FALLERS

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Abstract

Simple reaction time, the Berg Balance Scale, the ABC Scale and postural sway were studied in order to determine cutoff scores of the aforementioned variables as well as develop a model used in the prevention of fallers within the elderly community. One hundred and fifty fallers and one hundred and fifty non-fallers were evaluated throughout the study and results indicated that non-fallers have significantly faster reaction times, have higher scores on the Berg Balance Scale and the ABC Scale as well as sway at slower frequencies when compared to fallers. Furthermore, all risk factors were subsequently entered into a logistic regression analysis and results showed that reaction time, the total Berg Score and the total ABC score contributed significantly to the prediction of falls with 91% sensitivity and 94% specificity. A second logistic regression was carried out with the same previous variables as well as all questions of the Berg and ABC Scale. Results from the regression analysis revealed that five variables were associated with fall status with 90% sensitivity and 93% specificity. Results from the following study would seem rather valuable as an assessment tool for health care professionals in the identification and monitoring of potential fallers within nursing homes and throughout the community.

Introduction

Falls present a substantial health problem among the elderly population. Approximately one third of community-dwelling people over 65 years of age will experience one or more falls each year (Shumway-Cook et al., 1997; Tinetti et al., 1988; Powell & Myers, 1995; Stelmach & Worringham, 1985; Spirduso, 1995; Hausdorff et al., 1997). Subsequently, the frequency increases to nearly 40% for those individuals over 80 years of age (Powell & Myers, 1995) and affects women more than men (Nickens, 1985).

Fall related injuries are the leading cause of non-fatal injury. Nearly 40% of falls occurring in the 65 and over population are admitted to the hospital for some type of treatment (Tideiksaar, 1988; Shumway-Cook et al., 1997). In 15% of the cases, the injuries suffered include fractures, bruises, soft tissue injuries and loss of dependence (Powell & Myers, 1995). Serious injury occurs in 6% of the elderly population (Spirduso, 1995) resulting, in some instances, in accidental death (Baker et al., 1984). Approximately 40 to 50% of fallers admitted to hospitals will be admitted to nursing homes (Tinetti et al., 1988; Shumway-Cook et al., 1997). Of those who did not suffer serious injury, many may experience significant restrictions in daily activities (Tinetti et al., 1988). As a result, the elderly population develop a fear of falling complex (Maki et al., 1991), a decrease in self confidence to accomplish normal activities of daily living and adopt a lifestyle of inactivity resulting in significant muscular atrophy, most noticeable in lower extremity strength (Tinetti, 1987; Wolfson et al, 1995).

This serious health problem deserves immediate attention due to the fact that human life expectan continually been increasing throughout history. In fact, it is in the present century that this increase has shown a dramatic acceleration. In Canada, individuals 65 years and older represented approximately 12% of the population in 1996, and this percentage is expected to increase to nearly 16% by the year 2016. (Statistics Canada, 1996). This "graying" effect is also reflective in the population who are aged 75 years and older (Timiras, 1994). This group also represents a fast growing portion of the total population increasing to an estimated 7 % by the year 2016 (Statistics Canada, 1996). In light of this increase, health care professionals must address several problems occurring within this particular population. One of the most important and common problems is related to falls (Baker et al., 1984).

Many studies have focused on the possible risk factors associated with falling in the elderly population. (Robbins et al., 1989; Campbell et al., 1989; Tinetti et al., 1988; O'Loughlin et al., 1993; Myers et al., 1996; Nickens, 1985). Typically, these risk factors are categorized into two distinct groups: intrinsic and extrinsic. Extrinsic or environmental factors are a direct result of one's environment such as improper footwear and unstable living conditions (Tideiksaar, 1997) whereas intrinsic factors consist of those factors related to the physiological changes associated with aging. Throughout the past two decades, many researchers have identified several intrinsic factors that have been found to be rather successful in the prediction of falls. These factors have been identified as medication use (Blake et al., 1988; Spirduso, 1995), loss of balance (Overstall et al., 1977), syncope (Tinetti et al., 1988), postural instability (Overstall et al., 1977; Okuzumi et al., 1996); visual impairment (Okuzumi et al., 1996), neurological disabilities (Morris et al., 1987) muscle weakness (Whipple et al., 1987; Shumway-Cook et al., 1997) as well as sensorimotor deficiencies (Stelmach & Worringham, 1985).

Balance has been shown to be an important predictor of falls within the elderly population (Berg et al., 1992). It is a component that is needed to accomplish a wide variety of daily living activities such as gardening, reaching for items in a cupboard as well as walking. Throughout the years, several instruments have been developed as a means of quantitatively measuring balance in the elderly population. These screening tools have been instrumental in evaluating the ability to maintain balance and subsequently, in the identification of those individuals who present a substantial risk of falling in the very near future. In fact, Shumway-Cook et al., (1997) stated that of all the functional tests, the Berg Balance Scale was, indeed, one of the most effective predictors for falls within community-dwelling adults. However, it has been reported that this tool is not entirely representative in relation to its predictability of completing more complex tasks or activities that are concerned with measuring steady-state postural control as well as anticipatory postural adjustments (Shumway-Cook & Woollacott, 2001).

It has been documented that the ability to maintain balance or a postural task involves additional attentional requirements (Lajoie et al., 1993; Lajoie et al., 1996; Shumway-Cook & Woollacott, 1999; Marsh & Geel, 2000). In fact, the attentional demands are subsequently increased in relation to the complexity of the task at hand. This notion is well supported by Lajoie et al., (1993) whom found that dynamic balance, or more specifically the ability to maintain an upright standing position, is substantially more attention demanding when compared to static equilibrium. It was further demonstrated that reaction times measured during these various attention demanding tasks illustrated higher measures in a broad support stance phase as opposed to a sitting position in a sample of young adults. In a follow-up study by Lajoie et al., (1996), they found that healthy elderly subjects displayed significantly slower reaction times in a narrow base support standing position when compared to the younger experimental group. These results would imply that additional attentional resources are required by the elderly population in order to maintain balance or an upright posture. It would be interesting to investigate if any significant differences would arise in a geriatric population who have a previous history of falling and those individuals whom have not experienced a fall.

Psychological factors, more commonly referred to the "fear of falling syndrome", have been linked to significant reductions of daily activities in fallers resulting in a loss of independence (Maki, 1991). Interestingly enough, this fear of falling has been observed in healthy subjects as well as those individuals who have a previous fall history (Silverton & Tideiksaar, 1989). As a result, this functional tool would present rather confounding results when used as an independent measure of fall status.

Reaction time has been studied extensively. Reaction time is defined as the length of time measured between the presentation of an unexpected stimulus and the onset of a response to that stimulus (Schmidt, 1993). Research within this area has shown that reaction time responses increase as one ages (Clarkson, 1978; Gottsdanker, 1982; Loveless, 1980; Pierson & Montoye, 1958). In fact, Birren et al., (1980) had stated that reaction time was one of the most sensitive markers of structural and functional deterioration in the aging central nervous system. This is a rather interesting factor because it has been hypothesized that the aged lose the ability to process relevant information when compared to younger subjects (Haywood, 1993). Based on the foundation of the "information loss model", Myerson and colleagues (1990) believe that both young and old subjects alike process and respond to external stimuli in a sequential order of steps, with each step lasting a precise amount of time and dependent upon the inverse relationship of the information available in the subject's environment. This would suggest that if very little information were available, the amount of time to process through each step would increase, whereas if more information were available the process would be significantly shorter. As a result, older adults would ultimately spend more time during each step when compared to younger subjects. This increase is even more noticeable when tasks become more attention demanding (Stelmach & Worringham, 1985; Jordan, & Rabbitt, 1977). In light of this evidence, it would seem fitting to study this parameter as a function of falls due to the fact that seniors must process many attention demanding factors when faced with the possibility of preventing a fall. By combining this factor with other well documented functional measures, namely the Berg Balance Scale, the ABC scale as well as postural sway, we believe to be focusing on the three entities that make up postural control; steady-state, reactive and anticipatory responses (Shumway-Cook & Woollacott, 2001).

The purpose of the present study is to evaluate reaction time, the Berg Balance Scale, the Activities-Specific Balance Confidence Scale as well as postural sway and to determine an effective model with the underlying purpose of predicting falls in community-dwelling older adults. In addition, we would like to produce important cutoff scores with regards to the aforementioned variables in order to provide health care professionals with a valuable tool allowing them to successfully monitor fall status for the aged in the community and in senior residences.

Methods

Subjects

Three hundred subjects were tested during the course of this study after giving informed consent. Table 1 illustrates the descriptive statistics with regards to our study population.

Insert Table 1 here

The subject pool was subsequently divided into two equal groups of one hundred and fifty and categorized as fallers and non-fallers. All participants were selected within the Sudbury community, the local YMCA, nursing homes and senior residences. Inclusion criteria for the fallers category consisted of one or more falls during the past year.

For the present study, we have adopted the definition of a fall as defined by the Kellogg International Work Group on the Prevention of Falls by the elderly (1987) and the World Heath Organization (WHO): "A fall is an event which results in a person coming to rest inadvertently on the ground or other lower level and other than as a consequence of a violent blow; loss of consciousness or sudden onset of paralysis". Cohorts in the falling category were rejected if they suffered from any type of neurological disorder or physical limitations that could affect their ability to stand unsupported in an orthostatic position for four one-minute trials. As for the non-faller experimental group, they were accepted as eligible participants if they never sustained a fall, and were able to walk without the dependence of a walking aid. None of the subjects were familiar with the purpose of the study and they were instructed that they had the right to withdraw at any time during the testing trials.

Task and Apparatus

All subjects were asked to complete five experimental tasks ranging from answering questionnaires to performing specific balance and motor skills. Subjects were asked to complete two questionnaires. The first questionnaire consisted of a fall history and health status questionnaire. This provided us with important background information with regards to general health, history of falling, medication use and the activities of daily living of each participant. This information allowed us to establish health status among subjects in order to determine if they suffered from any type of serious medical problems that could significantly affect their performance in this study. At the end of the testing session, visual acuity was evaluated by means of a Snellen visual test in order to ensure subjects were able to participate in the testing sessions with normal or corrected vision.

The second questionnaire consisted of the Activities-Specific Balance Confidence (ABC) Scale. This item consisted of a 16-item subscale where subjects were asked to rate their confidence levels when asked to complete a number of various activities.

The next test the subject's were asked to complete was the Berg Balance Scale. This scale consisted of a 14-item balance specific activities ranging from sit to stand to standing on one leg. Participants are scored on a scale of 0 to 4 and ranked depending on their ability to successfully complete the tasks.

The fourth component of the study consisted of evaluating postural sway and reaction time. Subjects were asked to remove their shoes and stand on a Kistler force platform with their feet together, placed in an orthostatic position. Maintaining this stance was the primary task. The secondary task involved recording simple reaction times as all subjects were instructed to respond verbally "top" as soon as the auditory stimulus is presented while keeping their posture as straight as possible on the Kistler platform. The auditory stimulus was sampled at a rate of 5000 Hz and lasted approximately 50 ms. A microphone recorded the verbal cues and relayed the analog information to the computer system. Four one-minute trials were collected presenting approximately 7 to 8 auditory stimuli per experimental trial. Postural sway was monitored by means of an online digital computer program recording the center of pressure (COP) from the force plate during each trial. This parameter will be assessed through the interpretation of oscillation frequency modes (with the mode being defined as the frequency occurring the most frequently as measured by a Fourier Analysis) for each experimental group. Reaction time was measured from the onset of the auditory beep to the beginning of the "top" response by the study participants

Data Analysis

Data analysis of the experimental data was made possible by means of the STATSOFT software program. Analysis of variance was used to test the statistical significance of mean differences between fallers and non-fallers with regards to reaction time, postural sway frequency modes, total score of the Berg Balance Scale as well as the mean score of the ABC scale. A stepwise logistic regression was used in order to determine the best predictive model for falling in the elderly population. For this particular model, fall history was coded as 1 for non-fallers, 2 for fallers and was used as the dependent variable.

Lastly, a logistic regression was then used to determine a cut-off score for the Berg scale, the ABC scale and simple reaction time in order to identify those individuals at risk of falling.

Results

Attentional Demands

The mean and standard deviations of simple reaction time for healthy elderly and fallers are presented in Figure 1. A one-way Analysis of Variance revealed a significant (Group) difference ($F(1,304) = 299.1$, $p<.01$). These results would seem to indicate that the healthy elderly group displayed significantly faster reaction times than the faller experimental group.

Insert Figure 1 here

Postural Sway

The mean and standard deviations of postural sway frequency modes for healthy elderly and fallers are presented in Figure 2. Postural oscillations for both experimental groups were measured by means of a Spectral Fourier Analysis for both anterior-posterior (AP) and lateral planes. A two-way ANOVA (Group X Oscillation plane) revealed a significant Group main effect with respect to frequency mode ($F(1,304) = 13.9$, $p<.01$). As a result, fallers seem to oscillate at a higher frequency when compared to the healthy elderly. It was also shown that postural oscillations were much more prevalent in the lateral plane ($F(1,304) = 30.7$, $p<.01$). However, the Group X Oscillation plane interaction was not statistically significant.

Insert Figure 2 here

Activities Specific Balance Confidence (ABC) Scale

The mean and standard deviations for total score on the ABC Scale for healthy elderly and fallers are presented in Figure 3. A one-way Analysis of Variance was performed for the total score results of the ABC Scale. The results from the analysis showed that fallers had significantly lower overall scores than non-fallers ($F(1,304) = 323$, $p<.01$).

Insert Figure 3 here

Berg Balance Scale

The mean and standard deviations of the total Berg Balance Scale scores for healthy elderly and fallers are presented in Figure 4. A one-way Analysis of Variance was performed for the total score results of the Berg Scale. The results from the analysis showed that fallers had significantly lower overall scores than the healthy elderly on the Berg Balance Scale ($F(1,304) = 254$, $p<.01$).

Insert Figure 4 here

Predictive Models with regards to Fall Status in a Geriatric Population

A forward Wald logistic regression was performed in order to produce a model with the underlying purpose of predicting those individuals at risk of falling. In the first logistic regression model, the predictors entered into the analysis were age, the total Berg Balance Score, the total ABC score, mean postural sway frequency modes and simple reaction time. The logistic regression analysis showed that three predictors contributed significantly to the prediction of falls. These included the total ABC score, simple reaction time as well as the total Berg Balance score.

Table 2 displays the regression coefficients (B), the standard errors as well as the intercept (constant), for the significant predictor variables. The regression coefficients for the three predictors are significant at the .01 significance level.

Insert Table 2 here

Based on the results of the first logistic regression, the final model for the prediction of falls is extracted and is illustrated by the following equation:

> Likelihood of falling = 100% x exp(5.30 - .040 (total ABC score) + .014 (simple reaction time) - .235 (total Berg score) / {1 + exp (5.30 - .040 (total ABC score) + .014 (simple reaction time) - .235 (total Berg score)}

In order to evaluate the relevance of the proposed model, we investigated both the sensitivity and specificity of senior fall status and the results seem to indicate scores of 91% and 94% respectively.

Intercorrelations of Fall Predictor variables

Intercorrelations between predictor variables were analyzed in order to determine which variables were highly correlated. Table 3 displays the correlation coefficients of the risk factors studied that are significant at the .05 level. The results illustrated that the total Berg Balance Scale Score and the total ABC Score had the highest correlation whereas frequency mode in the anterior/posterior direction and the total Berg score was found to be not statistically significant. Due to the fact that many of the functional balance tests have many similarities, it was hypothesized that a second model might be more effective with the hope of eliminating any redundancies found within the Berg Balance scale and the ABC scale.

Insert Table 3 here

For this particular reason, a second logistic regression model was evaluated in order to determine if selected questions from the underlying balance and psychological measures were significant predictors in fall status. For this model, the predictors entered into the analysis consisted of age, the Berg Balance Scale (14 individual questions), the Activities-specific Balance Scale (16 individual questions), mean postural sway frequency modes and mean simple reaction time. The regression analysis showed that five predictors were significant contributors of falls. Simple reaction time was the most significant predictor followed by question 12 of the Berg Scale (placing each foot alternately on the stool), question 14 of the Berg Balance Scale (standing on one leg), question 2 of the ABC Scale (walking up or down stairs), and question 14 of the ABC scale (step onto or off an escalator while holding onto a railing),

Table 4 displays the regression coefficients (B), the standard errors as well as the intercept (constant), for the significant predictor variables. The regression coefficients for the five predictors are significant at the .05 significance level.

Insert Table 4 here

In light of the results from the second logistic regression, the final model for the prediction of falls is illustrated by the following equation:

Likelihood of falling = 100% x exp(-3.036 +.015 (Reaction Time) - .673 (Berg 12) - .966 (Berg 14) - .023 (ABC 2) - .019 (ABC 14) / {1 + exp (-3.036 +.015 (Reaction Time) - .673 (Berg 12) - .966 (Berg 14) - .023 (ABC 2) - .019 (ABC 14)

A descriptive example of the model is illustrated by the following situation. The probability of predicting a fall for an elderly individual who recorded a simple reaction time of 600 ms, scored 4 and 3 for Berg 12 and 14 respectively, 80 for ABC question 2 and 70 for ABC question 14, would present a 6% chance of sustaining a fall. On the other hand, if an individual recorded a simple reaction time of 650 ms, scored 2 and 1 for Berg 12 and 14 respectively, 40 for ABC question 2 and 30 for ABC question 14, this particular individual would be more likely to sustain a fall with a predicted probability of 94% based on the results of the logistic model.

Sensitivity and specificity values were evaluated for this particular model based on the assumption that a faller was identified with a value of 1.5 or above due to the fact that non-fallers were coded as 1 and fallers coded as 2 throughout the statistical analysis. Interestingly enough, the model is 90% sensitive and 93% specific with regards to its predicting power.

Cutoff Scores in the Prediction of Geriatric Fallers

The results from the Berg scale, the ABC scale and simple reaction time were further assessed in the hope of producing significant cutoff scores that will successfully classify those at risk of falling. With regards to the Berg Balance Scale, a cutoff of 46 and above was determined. With this cutoff, sensitivity and specificity values are 81 and 83% respectively.

Insert Figure 5 here

Further analysis of the ABC scale revealed a cutoff score of 66% and above. With this value, we are able to correctly classify 85% of those with a history of falls (sensitivity) and 85.5% of whom do not present a history of falling (specificity).

Insert Figure 6 here

Simple reaction time was the last variable to be assessed. It was found that a reaction time of 555 ms and above was the cutoff score that significantly classified 83%

of those with a fall history as well as 84% of those individuals whom have yet to sustain a fall.

Insert Figure 7 here

Discussion

The main purpose of this study was to evaluate several risk factors linked to the phenomenon of falling and to produce a predictive model in the hope of correctly identifying those individuals susceptible to falling. Several risk factors were evaluated as possible contributors to fall incidence in the elderly population. The risk factors included were the Berg Balance Scale, the Activities-Specific Balance Confidence (ABC) Scale, simple reaction time and postural sway. Each factor was assessed individually in order to produce a fall prevention model and subsequent cutoff scores as a means of differentiating fallers from non-fallers.

With respect to the Berg Balance Scale, it was found that fallers had significantly lower scores than non-fallers. In a similar study, Shumway-Cook et al., (1997) found a mean total Berg Score of 52.6 for non-fallers and 39.6 for fallers. However, these results are representative of community-dwelling elderly adults. In the present study, average total Berg scores were found to be 50 and 36.5 respectively for non-fallers and fallers, results that include both community-dwelling elderly and nursing home residents. It would seem that elderly individuals that score 50 on the Berg Balance Scale would present a 10 percent chance of sustaining a fall whereas a score of 36 and lower would reflect a 90 percent chance of falling. This data compares relatively well to that developed by other researchers (Shumway-Cook et al, 1997).

Through further investigation of the Berg Balance Scale, we proceeded to the determination of a cutoff score that would be statistically successful in predicting elderly fallers from non-fallers. Previous attempts in this field of study have suggested inconsistent findings. In one study, Berg et al., (1992) found a cut-off of 45 with a population of 70 acute stroke patients. In another instance, Shumway-Cook et al., (1997) determined a cutoff score of 49 based on a sample of 44 community-dwelling older adults. In the present study, we found that a cutoff score of 46 was statistically effective in predicting falls in the elderly community. Based on the data provided by Shumway-Cook et al. (1997) and the results from the present study, it seems rather evident that a 3-point cutoff differential would seem large enough to omit those potential individuals whom could present a serious risk of falling. By adopting a new cutoff score, the sensitivity and specificity of correctly classifying fallers and non-fallers is 81 and 83% respectively.

Postural sway frequency modes were analyzed and even though no significant interaction was found, the results showed that fallers had significantly higher oscillation frequency modes when compared to healthy elderly. Furthermore, it was determined that the subsequent oscillations were more prevalent in the lateral plane, findings that are well supported by Okuzumi et al., (1996).

Reaction time is a physiological entity that has been studied extensively in the research literature and has been linked as a causal factor in the incidence of falls in the elderly population. It is widely accepted that reaction time, or subsequently, general cognitive motor responses for that matter, all decline as one ages (Clarkson, 1978; Loveless, 1980). Several studies have been successful in proving that younger subjects react significantly faster to a simple reaction task when compared to older adults. More importantly, recent evidence has suggested that reaction time is a rather important entity used in distinguishing between fallers and non-fallers. This is in agreement with the findings of Lord et al., (1999). They believe that reaction time was one of the best predictors of postural sway in a geriatric population. Their findings showed that elderly individuals displayed increased sway patterns in the lateral plane during an upright tandem position. Those individuals whom were unable to hold the position required a forward step as a protective mechanism. When you couple this with the fact that reaction time has a tendency to decrease with age, the elderly individual may not have enough time to react in order to prevent the fall resulting in serious injury. The results from the present study demonstrate that when subjects are presented with a narrow base of support in an upright postural task, non-fallers displayed faster reaction times than fallers, recording reaction times of 468 ms compared to 728 ms for their falling counterparts. As a result, non-fallers seem to be more in measure of reacting in a timely matter in order to brace themselves for the fall or prevent it altogether. It is interesting to note that Lajoie et al., (1996) found comparatively similar results with healthy elderly subjects with average reaction times of 450 ms.. In light of this evidence, it seems evident that reaction time is a very important factor in the study of falls. Through further investigation of reaction time, a cutoff score of 555 ms was determined in the hope of distinguishing fallers from non-fallers. It seems rather evident that, in a similar testing protocol, elderly individuals whom score above a reaction time of 555 ms presents a very high predisposition of sustaining a fall or a fall related injury.

Psychological factors associated with fall risk have received important attention throughout the past decade. This fear of falling syndrome has significant implications on an elderly's independence level and results in a loss of confidence in performing activities of daily living. Evidence through the present study have suggested that fallers have a significantly lower overall ABC score when compared to their non-faller counterparts. As a result, those individuals with a fall history are more affected by the fear of falling complex and seem to be those who are more restricted in their everyday activities. Similar results were found by Powell & Myers (1995) but the difference was not statistically significant. In fact, Myers et al., (1996) found that fallers obtained an overall score of 53.7 whereas non-fallers scored 67.4 but the results failed to reach any level of statistical significance. In the present study, a score of 83.5 and 47.3 were determined for non-fallers and fallers respectively and the latter results were indeed statistically significant. In a further attempt to quantify fear of falling, a cutoff mark was established in order to allow for the positive identification of elderly individuals who present a substantial risk of falling. Results showed that a score of 66% was indeed a reliable means of predicting a future fall. In fact, this score was highly specific and sensitive with values of 85.5 and 85% respectively.

Based on the sample size of the present study, two logistic regression equations were performed in the hope of determining the best fall prevention model. In the first model, age, the total Berg Balance score, the total ABC score, simple reaction time and mean postural sway frequency modes were entered into the analysis. In the second model, the entire 14 questions from the Berg Balance scale, the 16 questions from the ABC scale, simple reaction time and postural sway frequency modes were entered. Age was not entered into the second regression equation due to the fact that it was not a significant predictor in the first model even though age means differed by 6 years between experimental groups.

Interestingly enough, both models have somewhat identical values with respect to sensitivity and specificity values. However, upon closer evaluation of the two predictive models, the second one seems the be highly effective and somewhat more accurate with regards to it's prediction capabilities for the following reasons. In the first instance, by including all questions from the various fall predictors studied, we seem to have eliminated any redundancies found within the Berg and ABC scales. Based on these results, we realized that several predictors were highly correlated due to the fact that vast majority of the questionnaires content measured, one way or another, a common aspect of balance. In light of this evidence, we believe that the second predictive model provides more accuracy in monitoring falls by eliminating those redundancies. A second advantage with regard to the aforementioned model is its administration time. By eliminating all the questions that were not significant contributors in the second model, we have now developed a 5 item model that is 90% sensitive and 93% specific in it's predictability power. This would make for an important measurement tool used by various health care professionals in identifying and monitoring those at risk of falling and subsequently injuring themselves.

Conclusion

The physical act of falling is a very common occurrence in the elderly population and one that presents a substantial health problem among the elderly due to the overwhelming rise in human life expectancy. The purpose of the following study was to develop a relatively simple fall predictive model that can be used by the vast majority of health care professionals, in various settings, with the hope of monitoring and preventing this terrible occurrence in the aged. This would allow nurses, physiotherapists, and other health care workers to identify those individuals who present a substantial risk for falling and perhaps enroll these seniors in a fall prevention strategy program. Such a strategy program would ensure additional safety measures to the elderly citizens whom require such attention and could indeed result in significantly lower incidences of falls. In turn, this would most definitely lead to reduced morbidity, mortality, and substantial lower health related costs to falls and fall related injuries. However, even though the results have shown this tool to be statistically effective in the prediction of falls, it would be of serious interest to validate this tool by means of a 6-month or a one-year follow-up study consisting of an elderly sample.

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Table 1
Descriptive Statistics of Experimental Groups

	Fallers		Non-fallers	
	Mean	**St. Dev**	**Mean**	**St. Dev**
Age (years)	80.85	7.38	74.57	6.31
Weight (lbs.)	148.44	30.39	148.53	29.89
Height (cm)	64.77	3.70	63.99	3.81
	Males	**Females**	**Males**	**Females**
Gender	50	100	49	101

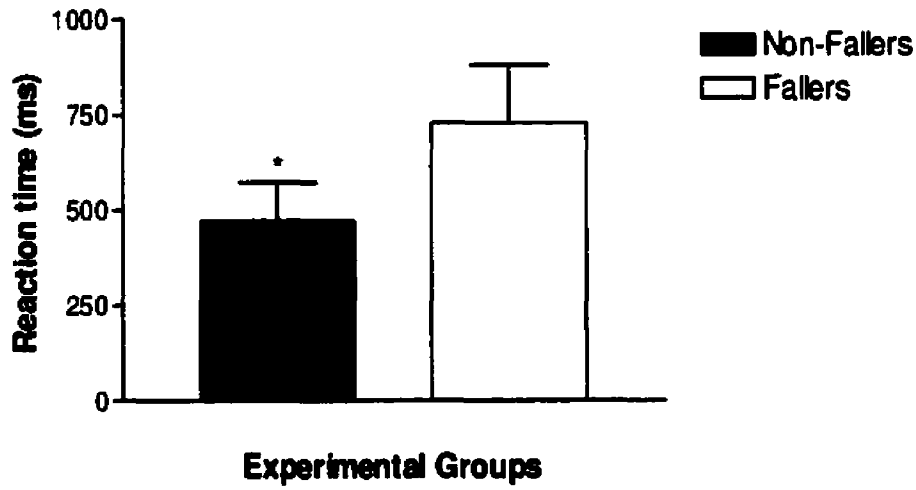

Figure 1. Mean reaction time and standard deviations between fallers and non-fallers
* Means are statistically significant between experimental groups at the .01 level.

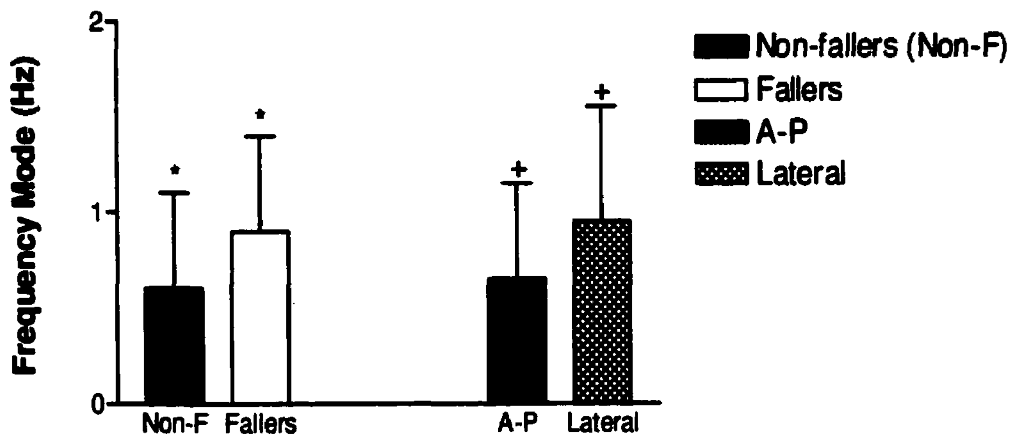

Figure 2. Mean oscillation frequency modes and standard deviations between fallers and non-fallers.

*Fallers oscillate at a higher frequency when compared to healthy elderly at the .01 level of significance.

+Postural oscillations are more prevalent in the lateral plane at the .01 level of significance.

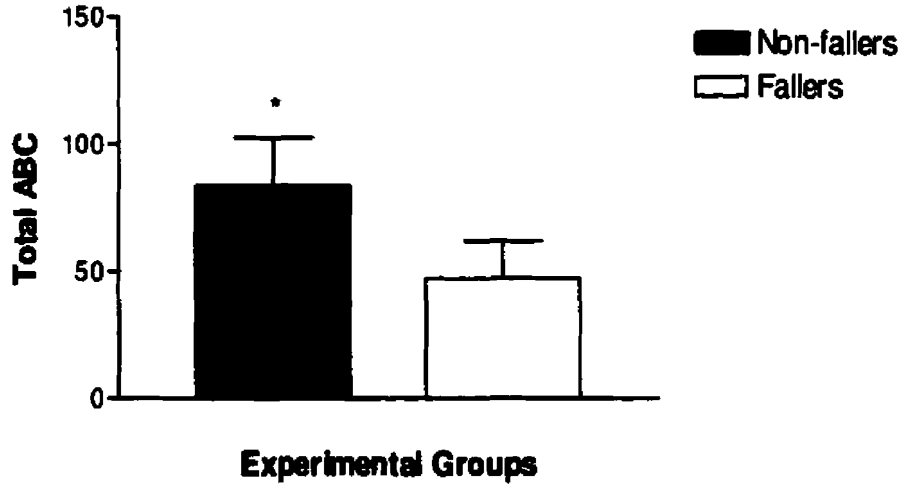

Figure 3. Mean total ABC score and standard deviations between fallers and non-fallers
* Means are statistically significant between experimental groups at the .01 level.

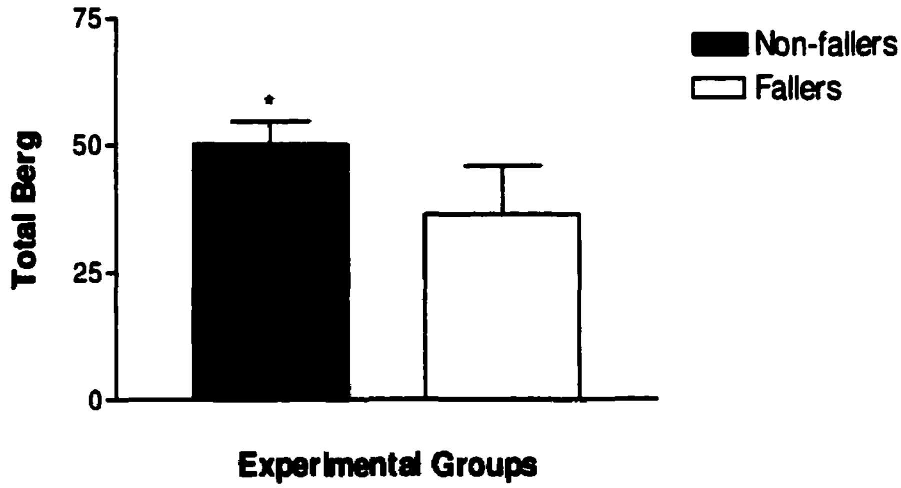

Figure 4. Mean total Berg score and standard deviations between fallers and non-fallers
* Means are statistically significant between experimental groups at the .01 level.

Table 2
Forward Logistic Regression of Fall Predictor Variables on Fall Status in a Geriatric Population: First Predictive Model.

Predictor Variables	B	S.E.
Mean ABC Score	-.0402**	.0138
Mean Reaction Time	.0136**	.0024
Mean Berg Score	-.2354**	.0526
Constant	5.297	2.3029

** $P < .01$

Table 3
Correlation among Predictor Variables.

Variables	Berg Scale	ABC Scale	Reaction Time	Ant/Post Sway	Lateral Sway
Berg Score	1.00	.70*	-.54*	-.03	-.13*
ABC Score	.70*	1.00	-.62*	-.21*	-.15*
Reaction Time	-.54*	-.62*	1.00	.12*	.18*
Ant/Post Sway	-.03	-.21*	.12*	1.00	.36*
Lateral Sway	-.13*	-.15*	.18*	.36*	1.00

• P<.05

Table 4
Forward Logistic Regression of Fall Predictor Variables on Fall Status in a Geriatric Population: Second Predictive Model.

Predictor Variables	B	S.E.
Mean Reaction Time	.015**	.002
Berg Question 12	-.673**	.217
Berg Question 14	-.966**	.268
ABC Question 2	-.023**	.008
ABC Question 14	-.019*	.008
Constant	-3.036	1.496

* P<.05
** P < .01

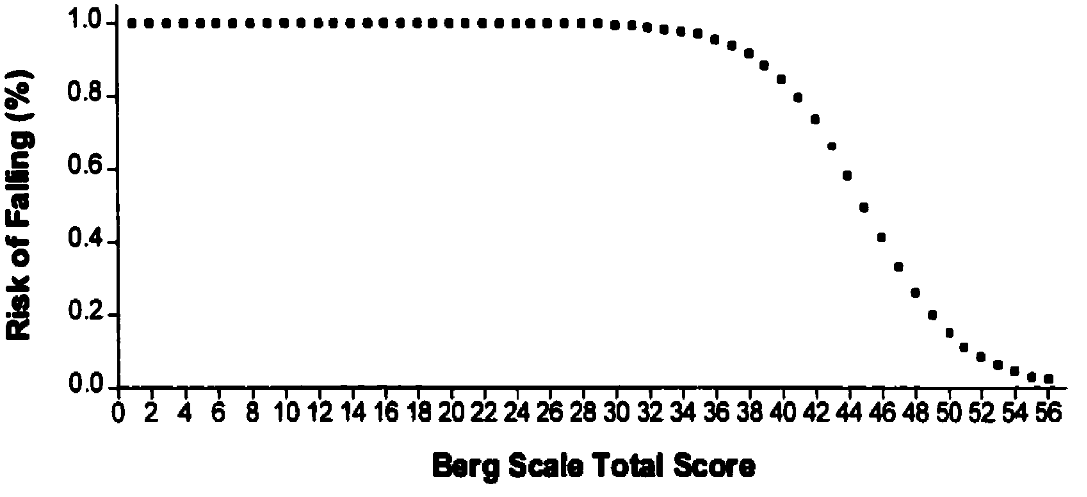

Figure 5. Predicted probability of falls as a function of the Berg Balance Scale.

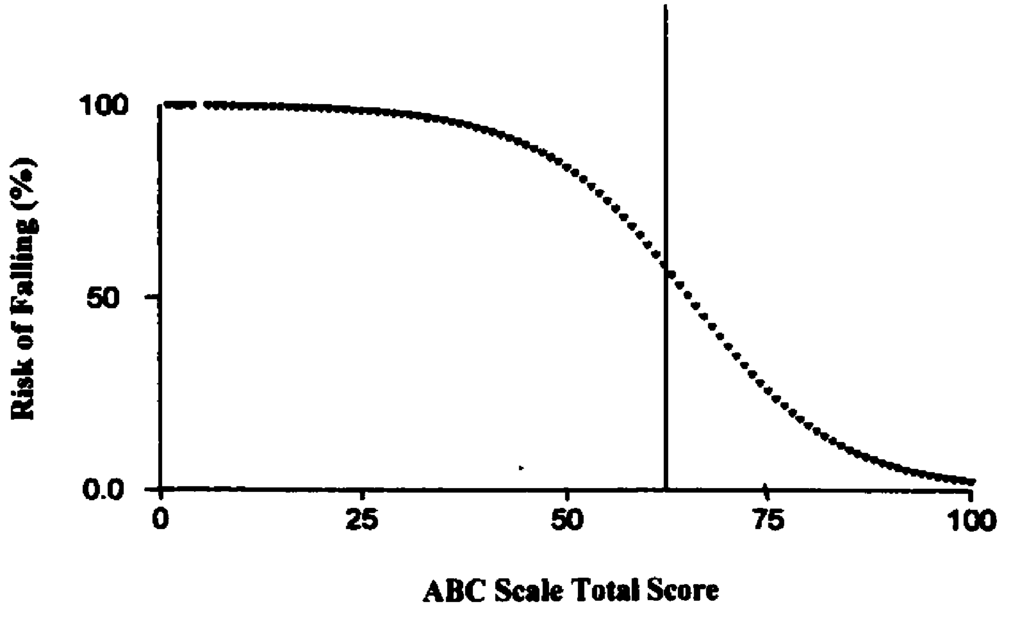

Figure 6. Predicted probability of falls as a function of the ABC Scale.

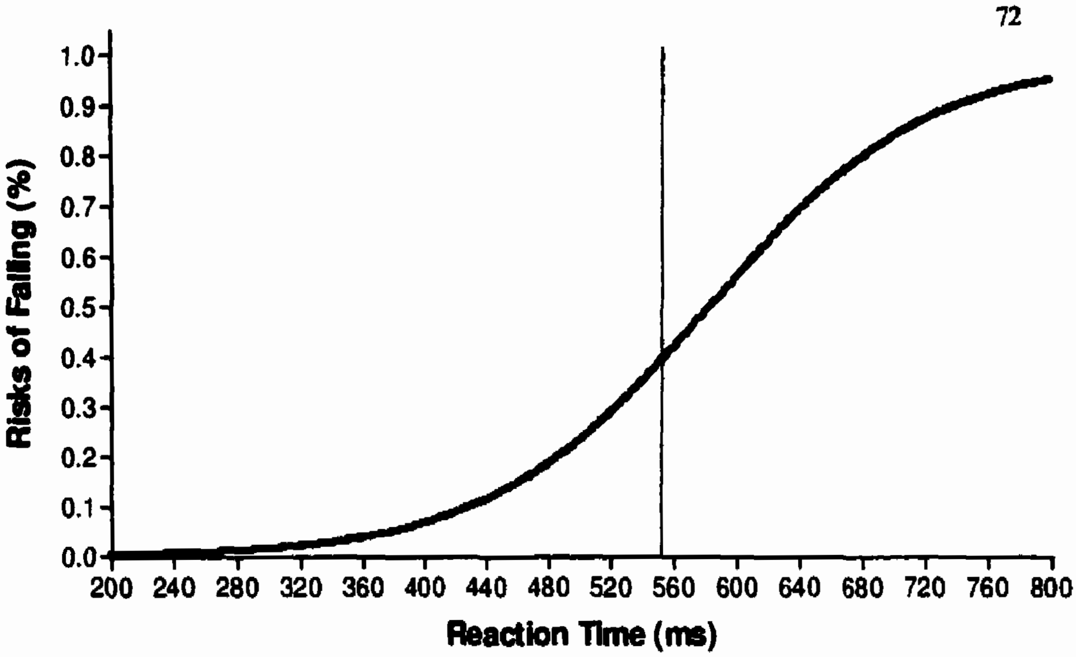

Figure 7. Predicted probability of falls as a function of reaction time.

CHAPTER IV

CONCLUSION

Based on the results of the present study, it was determined that fallers scored lower on all of the risk factors evaluated when compared to non-faller elderly subjects. It was found that they achieved overall lower scores on the Berg Balance Scale, the ABC Scale, and with regards to simple reaction time. Further analysis revealed significant cutoff predictors that could be used as successful identifiers for potential fallers. This valuable information could be used by nurses, physiotherapists, occupational therapists as well as family physicians for any elderly individual who presents a risk of falling.

Even though many functional tests have been developed with the hope of identifying potential fallers, these tests are, in most cases, rather long to administer and require specific instrumentation. With this in mind, it was in the author's best interest to conduct a logistic regression analysis in order to identify which factors from specific functional balance tests could significantly identify a faller. The results from the analysis uncovered five significant predictors that were highly sensitive and specific. This new prevention model would in fact be less time consuming and would provide rather accurate findings with respect to fall status.

It would be of further interest to continue this study in the sense of a validation measure with respect to this new model. This new study would consist of monitoring a sample of randomly selected elderly participants over a 6-month period. All subjects would be called to be evaluated on the 5-items that were significantly identified in the prediction model. Results from this study would indeed provide a more reliable functional tool, one that health care professionals could feel confident in using on a daily, monthly or yearly basis.

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Appendix 1

The Berg Balance Scale

BALANCE SCALE

NOM:________________ AGE:____________

Developed in partial fulfillment of Master of Science degree. McGill University : K. Berg, 1988.

1. **SITTING TO STANDING**

Instruction:

Please stand Up. Try not to use your hands for support.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to stand no hands and stabilize indep.	able to stand indep. using hands	able to stand using hands after several tries	needs minimal assist to stand or to stabilize	needs moderate or maximal assist to	

2. **STANDING UNSUPPORTED**

Instruction:

Stand for two minutes without holding.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to stand safely 2 minutes	able to stand 2 min. with supervision	able to stand 30 seconds unsupported	needs several tries to stand 30 sec.	unable to stand 30 sec. unassisted	

IF SUBJECT ABLE TO STAND 2 MINUTES SAFELY, SCORE FULL MARKS FOR SITTING UNSUPPORTED. PROCEED TO POSITION CHANGE STANDING TO SITTING

3. **SITTING UNSUPPORTED FEET ON FLOOR**

Instruction:

Sit with arms folded for two minutes.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to sit safely and securely 2 minutes	able to sit 2 minutes under supervision	able to sit 30 seconds	able to sit 10 seconds	unable to sit without support 10 seconds	

4. **STANDING TO SITTING**

Instruction:

Please sit down.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
sits safely with minimal use of hands	controls descent by using hands	uses back of legs against chair to control descent	sits indep. but has uncontrolled descent	needs assistance to sit	

5. **TRANSFERS**

Instructions:

Please move form chair to chair and back again. One way toward a seat with armrests and one way toward a seat without armrests.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to transfer safely with minor use of hands	able to transfer safely: definite need of hands	able to transfer with verbal cuing and / or supervision	needs one person to assist	needs two people to assist or supervise to be safe	

6. **SANDING UNSUPPORTED WITH EYES CLOSES**

Instruction:

Close your eyes and stand still for 10 seconds

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to stand 10 seconds safely	able to stand 10 seconds with supervision	able to stand 3 seconds	unable to keep eyes closed 3 seconds but stays steady	needs help to keep from falling	

7. **STANDING UNSUPPORTED WITH FEET TOGETHER**

Instruction:

Place your feet together and stand without holding.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to place feet together indep. and stand 1 minute safely	able to place feet together indep. and stand for 1 minute with supervision	able to place feet together indep. but unable to hold for 30 seconds	needs help to attain position but able to stand 15 seconds, feet together	needs help to attain position and unable to hold for 15 seconds	

8. **REACHING FOWARD WITH OUTSTRETCHED ARM**

Instruction:

Lift arm to 90 degrees. Stetch out your fingers and reach forward as far as you can. (Examiner places a ruler at end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position.)

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
can reach forward confidentrly > 10 inches	can reach forward > 5 inches safely	cand reach forward > 2 inches safely	reaches forward but needs supervision	need help to keep from falling	

9. **PICK UP OBJECT FROM THE FLOOR**

Instruction:

Pick up the shoe / slipper which is placed in front of your feet.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to pick up slipper safely and easily	able to pick up slipper but needs supervision	unable to pick up but reaches 1-2 inches from slipper and keeps balance indep.	unable to pick up and needs supervision while trying	unable to try; needs assist to keep from falling	

10. **TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS**

Instruction:

Turn to lood behind you over toward left shoulder. Repeat to the right.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
looks behind from both sides and weight shifts well	looks behind one side only ; other side shows less weight shift	turns sideways only but maintains balance	needs supervision when turning	needs assist to keep from falling	

11. **TURN 360 DEGREES**

Instruction:

Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to turn 360 safely in < 4 seconds each side	able to turn 360 safely only in < 4 seconds	able to turn 360 safely but slowly	needs close supervision or verbal cueing	needs assistance while turning	

12. **COUNT NUMBER OF TIMES STEP TOUCH MEASURED STOOL**

Instruction:

Place each foot alternately on the stool. Continue until each foot has touched the stool four times.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to stand indep. and safely and complete 8 steps in 20 seconds	able to stand indep. and complete 8 steps > 20 seconds	able to complete 4 steps without aid with supervision	able to complete >2 steps ; needs minimal assist	needs assistance to keep from falling / unable to try	

13. **STANDING UNSUPPORTED ONE FOOT IN FRONT**

Instruction: **(DEMONSTRATE to subject.)**

Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead so that the heel of your forward foot is ahead of the toes of the other foot.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to place foot tandem indep. and hold 30 seconds	able to place foot ahead of other indep. and hold 30 seconds	able to take small step indep. and hold 30 seconds	needs help to step but can hold 15 seconds	loses balance while stepping or standing	

14. **STANDING ON ONE LEG**

Instruction:

Stand on one leg as long as you can without holding.

GRADING: Please mark the lowest category which applies

( )	( )	( )	( )	( )	
4	3	2	1	0	( )
able to lift leg indep. and hold >10 seconds	able to lift leg indep. and hold 5-10 seconds	able to lift leg indep. and hold = or > 3 seconds	tries to lift leg ; unable to hold 3 seconds but remains standing indep.	unable to or needs assist to prevent fall	

TOTAL SCORE: ( )

MAXIMUM = 56

COMMENTS:

Comment on source of balance proglem eg. mm. weakness. cerebellar deficits. neglect. general debility, postural hypotension. meds. etc.

Appendix 2

The ABC Scale

NOM: ____________________ AGE: ________

THE ACTIVITIES-SPECIFIC BALANCE CONFIDENCE (ABC) SCALE[1]

For each of the following activities, please indicate your level of self-confidence by choosing a corresponding number from the following rating scale:

0%	10	20	30	40	50	60	70	80	90	100%
No Confidence										**Completely Confident**

"How confident are you that you will <u>not</u> lose your balance or become unsteady when you...

1. ...walk around the house ? ________%
2. ...walk up or down stairs ? ________%
3. ...bend over and pick up a slipper from the front of a closet floor ? ________%
4. ...reach for a small can off a shelf at eye level ? ________%
5. ...stand on your tip toes and reach for something above your head ? ________%
6. ...stand on a chair and reach for something ? ________%
7. ...sweep the floor ? ________%
8. ...walk outside the house to a car parked in the driveway ? ________%
9. ...get into or out of a car ? ________%
10. ...walk across a parking lot to the mall ? ________%
11. ...walk up or down a ramp ? ________%
12. ...walk in a crowded mall where people rapidely walk past you ? ________%
13. ...are bumped into by people as you walk through the mall ? ________%
14. ...step onto or off of an escalator while holding onto a railing ? ________%
15. ...step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing ? ________%
16. ...walk outside on icy sidewalks ? ________%

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[1] Powell LE & Myers AM. The Activities-specific Balance Confidence (ABC) Scale. Journal of Gerontology Med Sci 1995 ; (1) : M28-34.