AN ABSTRACT OF THE DISSERTATION OF

Katherine B. Gunter for the degree of Doctor of Philosophy in Human Performance presented September 5, 2002.

Title: A Prospective Study of Functional Performance, Balance Self-Efficacy, and Bone Mineral Density in Community-Dwelling Elderly Women.

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In the United States, falls are the leading cause of unintentional death with one of every three people 65 years and older falling each year. Falls account for approximately 95% of hip fractures among older adults and falls to the side predominate hip fracture related falls in this population. However, risk factors for side and frequent falls are poorly understood. Furthermore, few data exist to explain differences in bone mineral density among older postmenopausal women. In particular, data regarding the timing of hormone replacement therapy (HRT) among older women is scarce. In the first aim of this dissertation, we examined changes in mobility and balance-related risk factors for side falls as well as differences in these risk factors according to fall status in a population of 107 independent, elderly women (> 70 yrs), who were followed over 2 years. We found hip abduction strength decreased ($p<.001$) in all subjects, with side-fallers exhibiting weaker hip abduction strength ($p=.008$), greater sway velocity ($p=.027$),

and slower performances on the tandem walk (p=.039) and Get Up and Go (p<.001) compared to non-fallers. For the second study, in the same population, we examined 2-year changes in balance self-efficacy (BSE) and the relationship of BSE to side fall risk factors and falls incidence. Results showed BSE at baseline was predictive of Get Up and Go, hip abduction strength and tandem walk at follow-up (p<.008), but that BSE decreased only among the non-fallers (p=.013). In the third study, we examined 3-yr hip bone mineral density (BMD) changes in women with distinct hormone replacement therapy (HRT) profiles: 1) no hormone replacement therapy (**NoHRT**), 2) HRT continually since menopause (**Continual**), 3) HRT begun 10 years after menopause (**Late**), 4) HRT initiated within 5 years (**New**), and compared the change in BMD of the hip across HRT groups. Only the **NoHRT** group lost bone over the 3 years (p=.014). We also assessed BMD of the lateral spine across levels of estrogen use in a sub-sample of participants and found long-term HRT users had significantly higher lateral spine BMD (p=.041) compared to women who had never been on HRT.

A Prospective Study of Functional Performance Balance Self-Efficacy, and Bone Mineral Density in Community-Dwelling Elderly Women

By
Katherine B. Gunter

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation upon request.

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Katherine B. Gunter, Author

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How is it possible that after 5 years of hard work the most difficult part to write is the acknowledgments? The excitement surrounding the finale is only eclipsed by the emotions experienced on the journey. Thankfully, as I arrive at this ultimate conclusion I am accompanied by all of those who have buoyed me throughout my five and a half years at Oregon State University. Were it not for the following very special individuals, I may never have made it to this point:

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CONTRIBUTION OF AUTHORS

Dr. Wilson C. "Toby" Hayes is the second author on the manuscripts entitled "Changes in Side Fall Risk Variables in Elderly Fallers. Results from a 2-Year Prospective Study" and "Balance Self-Efficacy Predicts Performance on Mobility and Balance-related Risk Factors for Side and Frequent Falls Among Community-Dwelling Elderly Women Over 70 Years." Dr. Hayes was instrumental in the development of the Side Fall Risk Index, a battery of tests to predict those at risk for a side fall. In addition, he provided invaluable expertise in the editing of the two manuscripts.

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DEDICATION

I dedicate this dissertation to the women of science who have paved the way and provided opportunities innumerable, in particular my mentors, Kathy Knutzen, Lorrie Brilla, and Christine Snow, and to all the brilliant women of science yet to come.

A PROSPECTIVE STUDY OF FUNCTIONAL PERFORMANCE BALANCE SELF-EFFICACY, AND BONE MINERAL DENSITY IN COMMUNITY-DWELLING ELDERLY WOMEN

CHAPTER 1

INTRODUCTION

Hip fractures in the elderly account for a large portion of the disability and mortality experienced by older Americans each year (Forsen, Sogaard, Meyer, Edna & Kopjar, 1999). The costs of nursing and medical services related to hip fracture have been estimated at 10 billion dollars annually and are expected to increase with the continued growth of the elderly population (Hayes, Myers, Robinovitch, Van Den Kroonenberg, Courtney & McMahon, 1996). In the United States, falls are the leading cause of unintentional death with one of every three people 65 years and older falling each year (Tinetti, Speechley & Ginter, 1988; Sattin, 1992; Hoyert, Kochanek & Murphy, 1997; National Center for Health Statistics, 2000). Hip fractures represent one of the most traumatic fall-related outcomes and data indicate over 95% of hip fractures are subsequent to a fall (Parkkari, Kannus, Palvanen, Natri, Vainio, Aho, Vuori & Jarvinen, 1999; Stevens & Olson, 2000). Even in the absence of a serious physical injury, falling contributes to increased fear of falling, loss of confidence and functional decline (Nevitt, Cummings, Kidd & Black, 1989; Dunn, Rudberg, Furner & Cassel, 1992; Kosorok, Omenn, Diehr, Koepsell & Patrick, 1992; Tinetti, Inouye, Gill &

Doucette, 1995; Tinetti, Liu & Claus, 1993). According to a recent report, 80% of women over 75 said they would rather die than experience a hip fracture that would result in being admitted to a nursing home (Salkeld, Cameron, Cumming, Easter, Seymour, Kurrle & Quine, 2000).

Identifying those at risk for hip fracture requires an understanding of the types of falls that result in hip fracture (Tinetti et al, 1995; Luukinen, Koski, Honkanen & Kivela, 1995). Data indicate that just over 1%-2% of the 30 million falls that occur annually among older adults results in hip fracture (Nevitt et al., 1989). In the last few years, clear evidence has emerged that falls to the side significantly increase the risk of hip fracture in older adults (Hayes Myers, Morris, Gerhart, Yett & Lipsitz, 1993; Greenspan, Myers, Maitland, Resnick & Hayes, 1994; Greenspan, Myers, Kiel, Parker, Hayes & Resnick, 1998). In the frail elderly the risk of a fracture increases 6-fold with a fall to the side and up to 20-fold from a fall on or near one hip (Hayes et al., 1993).

To date, there have been no published studies examining the etiology and mechanics of sideways falls or on the identification of elderly subjects at risk for sideways falls. Furthermore, no one has examined changes in side fall risk factors relative to changes in fall status. Such studies are necessary to ascertain whether individuals whose functional performances are more rapidly deteriorating are more likely to fall or to experience the type of fall that most often results in a hip fracture or other serious injury.

In addition to severe physical consequences, falls contribute to increased fear of falling, loss of confidence and increased functional decline (Maki, Holliday & Topper, 1991). Fear of falling has been associated with self-induced restrictions in activity that result in declines in muscular fitness, postural control, and mobility, all of which further increase ones risk of falling (Tinetti, Mendes de Leon, Doucette & Baker, 1994; Tinetti, Richman & Powell, 1990; Vellas, Cayla, Boucquet, dePemille & Albareded, 1987; Powell & Myers, 1995; Myers, Powell, Maki, Holliday, Brawley & Sherk, 1996). As such, it is important to consider the interplay between functional declines and changes in the psychological mediators of physical activity and subsequent functional performance, in order to best understand what deteriorates first and how best to intervene.

Finally, if we are to fully understand the complex portrait of a fall-related hip fracture we must consider changes in bone mineral density (BMD). Decreases in BMD are a normal consequence of aging, and the loss of BMD is estimated to account for as much as 80% of the decrease in skeletal strength. Average losses of 2% per year have been shown in studies of later stage postmenopausal women (15-30 years postmenopausal) (Xu, Wu & Yan, 1998). Compounded with decreases in functional performance and self-induced reductions in activity due to fear of falling, age-related losses in bone density reduce the fracture threshold and increase the risk of hip fracture.

Thus it is necessary to investigate changes in known side and frequent fall risk factors, examine changes in potential psychological contributors to side and recurrent fall risk, such as balance self-efficacy, and examine changes in bone mineral density among apparently healthy, independent, women over 70 years. Such research may provide insights into which factors should be the focus of intervention efforts and help us to paint a clearer portrait of the fall and fracture paradigm.

Risk Factors for Falls

A primary aim of this dissertation is to identify changes in fall risk factors that differentiate individuals at the greatest risk of an injurious fall from non-fallers and individuals who may fall, but who are at a lower risk of an injurious outcome. Falls in the elderly are rampant and have been studied quite extensively. The most often cited risk factors for falls include advanced age, female gender, fall history, impaired ability to carry out the activities of daily living, presence of disease or disability, the use of certain medications, poor reflexes, slower reaction time, reduced lower extremity strength, impaired gait, and visual impairment (Chu, Pei, Chiu, Liu, Chu, Wong & Wong, 1999; Ivers, Cumming, Mitchell & Attebo, 1998; Norton, Campbell, Lee-Joe, Robinson & Butler, 1997; Schwendner, Mikesky, Holt, Peacock & Burr, 1997; Lee & Kerrigan, 1999; Studenski, Duncan & Chandler, 1991).

However, despite that over 95% of hip fractures result from a fall, only 1%-2% of falls lead to a hip fracture (Nevitt et al., 1989; Tinetti, Speechley & Ginter, 1988; Sattin, 1992). It is likely that the characteristics of those 1-2% of hip fracture-related falls differ significantly from the majority of falls that do not result in serious consequences. If we hope to reduce fracture incidence it is essential that we work to elucidate what is unique about the 1-2% of falls that result in hip fracture.

Risk Factors for Injurious Falls

Factors associated with injurious falls include a history of multiple falls, a previous fall-related injury, difficulty rising from a chair, poor tandem gait, decrements in lower extremity strength and power, increased postural sway, slower reaction times, certain characteristics of gait, and impaired vision (Lord, Clark & Webster, 1991; Ivers et al., 1998; Norton et al., 1997; Resnick, 1999; Judge, Davis & Ounpuu, 1996; Lee et al., 1999). In a two-year surveillance study of 220 older adults in an assisted living environment, the number of falls was the only variable associated with having an injurious fall (Resnick, 1999).

It has been speculated that frequent fallers are more apt to fall sideways and it has been well established that falling to the side increases the risk of hip fracture 6 to 20-fold among frail elderly who fall directly on the hip (Parkkari et al., 1999; Greenspan et al., 1998; Hayes et al., 1996; Hayes et al., 1993). In a study of community-dwelling ambulatory elderly, falling to the side increased the risk of hip fracture 2.5 times and a fall directly on the hip increased the risk of hip fracture 5-fold (Wei, Hu, Wang & Hwang, 2001). Thus the greatest risks for injurious falls appear to be falling frequently and falling to the side.

Risk factors for Side and Frequent Falls

Numerous studies in recent years have identified falls to the side as perhaps the most significant risk factor for fall-related hip fractures (Wei et al., 2001; Slemenda, 1997; Parkkari et al., 1999; Greenspan et al., 1998; Hayes et al., 1996). However, aside from a case-control study including known side-fallers conducted in our laboratory, there are no published data that identify risk factors for falls to the side. Using data from our case-control study, we identified functional performance variables that discriminated known side-fallers from individuals who fell in other directions (White, Gunter, Hayes & Snow, 2001). These variables have been combined into a test battery referred to as the Side Fall Risk Index (SFRI) which includes the measures most predictive of side fallers in our case-control pilot study. Specifically, postural sway while in semi-tandem stance, hip abduction strength, poor performance on tandem gait, and asymmetry in velocity when stepping to the side, discriminated side-fallers from other-direction fallers (White et al., 2001). We found measures of knee and ankle strength, previously shown to be risk factors for falls (Lord & Clark, 1996; Lord, Rogers, Howland & Fitzpatrick, 1999; Whipple, Wolfson & Amerman, 1987; Wolfson, Judge, Whipple & King, 1995), were not predictive of side fallers in our case control study.

Risk factors for recurrent falls are more predominant in the literature. In a previous study examining differences between non-fallers, one-time fallers, and frequent fallers, we found performance on the Get Up and Go test discriminated frequent fallers from one-time fallers (Gunter, White, Hayes & Snow, 2000). In a recent study of single versus recurrent fallers among hospital in-patients, recurrent fallers were more likely to exhibit unsafe gait, be more confused, and were more apt to be on anti-depressants compared to single fallers (Vassallo, Vassallo M, Sharma JC, Allen Sharma & Allen 2002). These findings are consistent with the reports of Lipsitz et al (1991) who reported that frail, ambulatory, elderly, recurrent fallers were more functionally impaired, and were taking more medications. This study also determined that recurrent fallers were more apt to be women (Lipsitz, Jonsson, Kelley & Koestner, 1991).

Among independent elderly, risk factors for recurrent falls include a previous history of falls, use of psychotrophic medications, and slow walking speed (Luukinen, Koski, Laippala & Kivela 1995). In summary, mobility and balance-related risk factors for side and frequent falls include poor postural control in a static semi-tandem stance, poor performance on a tandem walk task, poor hip abduction strength, asymmetry in lateral stepping velocity, slow gait, and poor performance on the Get Up and Go task. In addition, the use of psychotrophic medications, as well as increased confusion have been identified as risk factors for recurrent falls. Thus the most efficacious approach to hip fracture prevention may be to target these side and frequent fall risk variables in intervention efforts.

Fear of Falling

In addition to severe physical consequences, falls contribute to an increased fear of falling in older individuals (Arfken, Lach, Birge, & Miller, 1994; Maki, Holliday , & Topper, 1991) and fear of falling has been identified as a risk factor for future falls among older adults (Tinetti et al., 1994; Tinetti et al., 1995). Fear of falling is typically operationalized in the literature as a continuum of self-confidence in the domains related to falling such as balance (Tinetti, Richman, & Powell, 1990). Research in this area is still novel and studies in community-dwelling populations have used a variety of measures to assess *fear of falling*. Methods vary from a single question asking participants if they are fearful, to indirect, situational specific balance and falls efficacy scales. Instruments consisting of multiple scaled questions are reputed to be more sensitive to change in fear over time (Velozo and Peterson, 2001). Research is predicated on Bandura's concept of self-efficacy, representing individuals' perceptions of their abilities in specific domains (Bandura, 1977). According to Bandura's theory, individuals' self-perceived capabilities within specific domains determine whether they will engage in particular activities. A person with low self-efficacy as it pertains to balance control while walking down stairs, but average self-efficacy while walking on uneven ground, would tend to avoid stairs, but feel confident walking on uneven ground. For such an individual, the question "Are you afraid of falling?" is insufficient to quantify fear as their fear is situation specific. Furthermore, in older adults, stronger self-efficacy is related to health promoting behaviors and increased physical function (Tinetti et al., 1994). Thus, measures of balance self-efficacy may provide a better metric of fall risk than a single question about fear.

We recently completed a study assessing changes in balance self-efficacy (BSE) over one-year in community-dwelling elderly fallers and non-fallers, and relating BSE to risk factors for side and frequent falls (Gunter, DeCosta, Hooker, White, Hayes, Snow, in press). We found that fallers exhibited lower BSE scores than non-fallers, and that BSE scores were stable over one year. In addition, balance self-efficacy was predictive of medio-lateral sway and performance on the Get Up and Go and tandem walk. However, in that study we included both men and women and did not examine differences in BSE by fall direction.

These factors highlight the importance of fear of falling as it relates to declining physical function and falls, the consequences of which are often institutionalization, and support the idea that fear of falling is a health problem that deserves attention in greater depth. The limited data relating balance self-efficacy to physical function portray psychological contributors to fear of falling as potential mediators of falls incidence (Maki, 1997). However, the relationship of balance self-efficacy to specific risk factors for side and frequent falls is unknown.

Bone Loss in the Elderly

To fully understand the fracture paradigm for older individuals, we must also consider changes in bone mineral density (BMD) in this population. There is little doubt that bone loss starts as early as the fourth decade of life. Between 25 and 45 years, estimates of loss average approximately 16% at the predominantly cancellous sites such as the trabecular vertebral tissue (Mautalen & Oliveri, 1999). Losses at the femoral neck average 5% between 25 and 45 years of age (Mautalen & Oliveri, 1999). The abrupt loss of estrogen following menopause exacerbates bone loss at all skeletal sites and contributes significantly to the increased risk of hip fracture in this age group. Five years after the onset of menopause, bone losses are less pronounced, but continue throughout life (Mautalen CA, Oliveri, 1999; Greenspan , Maitland, Myers, Krasnow & Kido, 1994). However, there are data that show an increasing rate of loss at the femoral neck after age 60 (Jones, Nguyen, Sambrook, Kelly & Eisman, 1994).

Risk Factors for Bone Loss

Years of published studies have confirmed the relationship between bone mass and the mechanical properties of bone with decreases in BMD estimated to account for as much as 80% of the decrease in skeletal strength (Singer, Edmondston, Day, Breidahl & Price, 1995). Thus, recognizing risk factors for bone loss in conjunction with risk factors for falls may help reduce fracture risk. Risk factors for low bone mass are well documented and include female gender, advanced age, estrogen deficiency, low body weight, previous fracture, and a family history of osteoporosis (NIH, 2000). Smoking, caffeine intake, and alcohol consumption are often associated with decreased bone mass as well (Need, Kemp, Giles, Morris, Horowitz & Nordin, 2002; Rapuri, Gallagher, Kinyamu & Ryschon, 2001; NIH, 2000). A low peak bone mass is a primary risk for osteoporosis in later life. Low levels of physical activity in youth, late menarche, and early menopause hinder the attainment of optimal peak BMD, and thus indirectly affect BMD in later life (NIH, 2000).

Senile osteoporosis is the term denoting age-related loss of bone that is independent of acute loss of sex hormones (Robey & Bianco, 1999). However, the mechanisms by which this phenomenon occurs have not been fully elucidated. Based on current evidence, it appears that age-associated bone loss is related to the inability of bone marrow stromal cells to deposit sufficient bone to compensate for the amount removed by osteoclasts (Eriksen, 1986; Robey & Bianco, 1999). It is hypothesized that inferior bone quality results from this as well. Whatever the mechanism, or contributors to bone loss in older adults, it is important to understand that bone loss is not the only predictor of fracture risk. Risk factors for falls are also important predictors of fracture risk and in the elderly, risk factors such as age, low body weight and low levels of physical activity impact both fracture risk parameters; BMD and fall risk. Thus, understanding how these risk factors vary together is important to prevent fractures in this population.

Hormone Replacement Therapy to Reduce Bone Loss

Hormone replacement therapy (HRT) is perhaps the most recognized and effective strategy to reduce postmenopausal bone loss (Barrett-Connor, 2002; The

Writing Group for the PEPI, 1996; Schneider, Barrett-Connor & Morton, 1997). However, current evidence regarding postmenopausal HRT is confusing and conflicting, making the decision regarding whether or not to use HRT in the management of osteoporosis a challenge for many women. Intervention with estrogens or combined estrogen/progestin has long been considered the gold standard for osteoporosis management and numerous controlled clinical trials have shown that estrogen intervention preserves bone at all the sites studied (Marcus et al., 1999; The Writing Group for PEPI, 1996; Felson, Zhang, Hannan, Kiel, Wilson & Anderson, 1993). However, recent data suggest that benefits to the skeleton resulting from HRT may be accompanied by other health risks.

The Women's Health Initiative (WHI) is a large research program focusing on defining the risks and benefits of strategies that could potentially reduce the incidence of heart disease, breast and colorectal cancer, and fractures in postmenopausal women. Recent data from one of the WHI studies suggest that taking conjugated equine estrogens, plus medroxyprogesterone acetate, increased the risk of heart attacks, strokes, other blood clots, and invasive breast cancer (Grady et al., 2002). The risks so outweighed the benefits that the study was stopped three years prior to its intended conclusion. This is the first time these results have been seen in a large randomized-controlled study of apparently healthy older women. A smaller study of women with coronary artery disease [Heart and Estrogen/progestin Replacement Study (HERS)] found a higher incidence of coronary events among HRT users in the initial stages of the study and no benefit after 4 years (Hulley et al, 1998). The women in the HERS study were older (mean age 67 years) and were recruited into the study based on a history of coronary artery disease (Hulley et al, 1998). However the majority of published studies, until very recently, have proclaimed HRT as a means to reduce the risk of cardiovascular events in addition to reducing bone loss (Nabulsi et al, 1998; Rosano and Fini, 2002).

Conflicting study results and varying individual risk profiles make choices regarding estrogen use difficult even with an evidenced-based approach. To complicate matters further, there are even fewer data available for women who are well past menopause and trying to decide whether to initiate HRT or for women who are long-term HRT users considering cessation of therapy. The HERS study suggests that older women who initiate HRT may be at an increased risk of cardiovascular events in the first year of HRT use (Hulley et al, 1998). However the positive effects of estrogen on bone do not appear to be mediated by the age of initiation (Schneider et al, 1997; Bjarnason, Alexandersen & Christiansen, 2002). For women hoping to cease HRT, data suggest that for the first two years after withdrawal of HRT, the rate of bone loss is similar to the rate of loss experienced in the first two years post menopause in untreated women (Tremollieres, Pouilles & Ribot, 2001). Thus decisions regarding treatment are even more difficult for older women whose risk of fracture is arguably higher than that of younger, newly postmenopausal women. More studies regarding the effects of HRT and the timing of HRT among older postmenopausal women are necessary for these women to be able to make evidence-based decisions about their skeletal health and fracture prevention strategies.

Statement of Purpose

The overall objective of this dissertation was three-fold. It is our contention that the fracture paradigm is multi-factorial and that fracture risk among independent, elderly women is dominated by individuals' susceptibility to falls in the sideways direction. However, it is unclear which aspects of physical function and which psychological parameters contribute to an increased risk of side falls. Furthermore, should a fall occur, it is important to consider changes in skeletal health in this population to determine whether or not skeletal changes may be altered by specific hormone replacement therapy intervention choices made even very late in life.

Our first study was designed to examine 2-year changes in specific balance and mobility related side and frequent fall risk factors. Our aim was to determine which previously identified risk factors for side and frequent falls change most dramatically and to determine whether changes in these variables differed in side-fallers compared to non-fallers and other-direction fallers. In our second study we assessed balance self-efficacy over 2 years in a population of known side fallers. Balance self-efficacy (BSE) refers to an individual's confidence in performing tasks without fear of losing one's balance. Specifically, we were interested in whether or not BSE changed over 2 years and whether changes in BSE differed between side fallers, non-fallers and other-direction fallers. In addition we evaluated the relationship between the psychological parameter BSE and physical function by using BSE at baseline to predict function 2 years later. In the third and final study presented in this dissertation, we examined changes in bone mineral density in this same independent, elderly, female population to determine whether choices regarding hormone replacement therapy altered the rate of change in bone among this cohort of women long past menopause. Specifically we evaluated the effects the timing of estrogen therapy has on BMD and bone loss at the total hip. In addition we examined the effects the timing of estrogen therapy had on BMD of the anterior-posterior and lateral spine at follow-up. Ultimately the results of these studies will contribute to the body of knowledge to determine whether changes in physical function, psychological health, or skeletal health are most profound in this population and which area would be the most efficacious to focus intervention efforts to reduce hip fracture incidence.

CHAPTER 2

LOW HIP ABDUCTION STRENGTH DOMINATES SIDE-FALL RISK IN ELDERLY WOMEN. A 2-YEAR PROSPECTIVE STUDY

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ABSTRACT

Falling to the side is associated with an increased risk of hip fracture in the elderly compared with falls in other directions. However, the etiology of side-falls is poorly understood. **Purpose**: The aim of this study was to examine 2-year changes in performance on risk factors for side falls among healthy, independent women over 70 years. **Methods:** We measured the two-year rate of change in hip abduction strength, tandem walk, Get Up and Go, sway velocity during semi-tandem stance, and lateral stepping velocity, and compared these changes between non-fallers ($n=41$), side-fallers ($n=36$), and other-direction fallers ($n=27$) (mean age 77 ± 4.5 years). **Results:** There were no differences in rates of change on risk factors for side falls between fall groups. However, hip abduction strength and tandem walk performance declined over two years ($p<.001$ and $p=.031$, respectively). When analyses were repeated controlling for age, these changes were eclipsed (Pillai's Trace=.040, $p=.406$). Side fallers exhibited weaker hip abduction strength and were slower on the Get Up and Go at baseline compared to non-fallers ($p=.025$ and $p=.04$, respectively). At follow-up, only hip abduction strength was different between groups, with side-fallers scoring lower than non-fallers ($p=.019$). In correlation analysis between physical activity and side-fall risk factors, only Get Up and Go ($r=-.35$, $p=.04$) and hip abduction strength ($p=.36$, $p<.001$) were related to physical activity. **Conclusion:** Hip abduction strength may be a sensitive and useful indicator of side-fall risk among women over 70 years. Furthermore, the association between physical activity and both hip abduction strength and Get Up and Go performance, suggests that the development of exercise programs targeting these variables may help reduce the risk of side falls in this high-risk population.

Key Words: functional decline; hip fracture risk; injurious falls

INTRODUCTION

Approximately 95% of hip fractures are the result of a fall (27). Thus, minimizing fall risk may be the most effective way to reduce hip fractures among older individuals. Data indicate that just over 1% of the 30 million falls that occur annually among older adults results in a hip fracture (22) suggesting the falls leading to hip fracture may be unique. In the last few years, clear evidence has emerged that falls to the side significantly increase the risk of hip fracture in older adults (9, 10, 14). In the frail elderly the risk of a fracture increases 6-fold with a fall to the side and up to 20-fold from a fall on or near one hip (13). However, the specific factors that increase the likelihood of a side fall are poorly understood.

Currently, we are validating regression models and refining an index containing the variables most predictive of a side fall (30). This index will be used to identify those at the greatest risk of experiencing a side fall. At present, the following variables are included in the index: 1) tandem walk; 2) sway velocity while in a semi-tandem stance position; 3) hip abduction strength; and 4) asymmetry in lateral stepping velocity. In a case control study in our laboratory, side-fallers were slower, weaker, had increased sway velocity, and greater asymmetry in lateral stepping velocity than other-direction fallers. However, it is unknown whether side-fallers exhibit increased rates of change as well as poorer scores on risk factors for side falls compared to non-fallers and other-direction fallers. Thus the prospective examination of side-fallers is necessary to better understand this high-risk group.

Most published studies examining risk factors for falls have collected baseline measures and prospective falls surveillance data but have not provided follow-up measurements on the risk factors used to predict falls incidence. Thus, the prediction of a subsequent event is modeled upon a prior measure without considering changes in the risk factor over the observation period. A plethora of data describes fallers as weaker, slower, and more challenged in their mobility than non-fallers (3, 8, 11, 12, 18, 19, 24, 25). And, because of the multi-factorial nature of falls, most of the models presented in the literature adequately predict fallers. Considering that only 1% of falls result in hip fracture, and that falls to the side dramatically increase hip fracture risk, we need to refine prediction models to identify the small percentage of elderly who are at the greatest risk of a fall that will result in a hip fracture.

In this prospective study our aims were: 1) to examine the two-year change in performance on specific risk factors for side falls among community-dwelling women over 70 years and 2) to determine whether performance in these variables differed in those who fell to the side compared to non-fallers and other directions fallers. We measured the rate of change in sway velocity during semi-tandem stance, hip abduction strength, lateral stepping velocity, tandem walk and Get Up and Go, and compared these changes between non-fallers, side-fallers, and other-direction fallers. We hypothesized that side-fallers would have poorer scores and steeper declines compared to other-direction fallers and non-fallers.

METHODS

Design

This was a two-year prospective study conducted between November 1998 and November 2001 at the Bone Research Laboratory, Oregon State University, Corvallis, Oregon. This study was ancillary to a larger, four-year falls surveillance study and subjects for this 2-year study were recruited from the falls surveillance database and entered into the study on a rolling basis over the course of one year. Subjects returned for follow-up testing two years after their initial test session. Falls surveillance was conducted between baseline and follow-up testing, and participants were categorized by fall status at follow-up.

Subjects

We recruited one hundred twenty-nine women, including fallers and non-fallers, from our fall surveillance database, who had also been tested on a collection of functional measures between November 1998 and November 1999 as part of a case-control study to identify performance variables specific to side-fall risk (30). Two years later, 107 women, aged 72-93 years (mean $\pm$ *SD*, 76.97 $\pm$ 4.47) returned to the Bone Research Laboratory and were re-tested on the variables specific to side-fall risk. Of the twenty-two individuals that did not return for follow-up, 4 had undergone surgery, 1 developed cataracts, 1 had a stroke, 3 moved out of state, another was caring for an invalid husband, 1 could not get transportation to the testing facility, 4 were lost to follow-up, and 7 did not wish to participate. Participants were excluded from analyses if they could not complete testing independently, without assistance. Two subjects were excluded on this basis and a third was excluded because she experienced a hip fracture late in the observation period and was bedridden for much of the time prior to follow-up testing. Thus analyses were performed on data from 104 subjects.

Participants completed extensive health history and physical activity questionnaires [Physical Activity Scale for the Elderly (PASE), New England Research Institutes, Watertown, MA], and were screened for medication use. All participants resided in the Mid-Willamette Valley in western Oregon. This study was approved by the Oregon State University Institutional Review Board and all subjects gave written informed consent prior to participation.

Falls Surveillance

Frequency of falls and fall characteristics were determined from falls surveillance using falls diaries, postcard mailings, and follow-up phone contacts. Participants received fall diaries upon entering the fall surveillance study and were instructed how to record their falls. Participants were mailed postcards every three months, upon which they indicated whether or not they had fallen during the past three months. If a fall was indicated on the returned postcard, participants were called and questioned as to the characteristics of those falls using a detailed questionnaire. A fall was defined as "an event that results in a person coming to rest unintentionally on the ground or other lower level" (28). Falls could have resulted from slips, trips, or perturbations. Falls resulting from an externally applied force (such as being struck by a cyclist or an automobile) were not recorded. Falls surveillance data were collected quarterly over the two-year observation period and revealed that 192 falls, among 63 women occurred between baseline and follow-up.

Characterizing side-fallers was a challenge and considerably more difficult than defining a side fall. There are no population studies of side-fallers and thus, no model as to what characterizes such an individual. Because the risk of fracture is six times greater when a fall occurs to the side (13), and because it only takes one side-fall to fracture a hip, side-fallers were characterized as anyone experiencing at least one fall in the sideways direction terminating with impact on the hip or side. Under this definition, side-fallers may have experienced falls in other-directions as well. However, other-direction fallers were characterized as individuals who fell forward and backward but had *no falls to the side and no falls terminating with impact on the hip or side.* By this definition, 41 participants were non-fallers, 36 were side-fallers, and 27 individuals fell *only* in directions other than to the side (other-direction fallers). There were no differences in age, height, weight, reported physical activity, medication use, presence of disease, or vision between fall groups (Table 2.1).

Table 2.1 Subject Characteristics by Group (means ± SD)[1]*

Variable	Non-fallers n=41	Side-fallers n =36	Other fallers n=27
Age (mean ± SD)			
Baseline	76.9 (4.0)	76.83 (4.25)	76.56 (4.82)
Follow-Up	78.66 (4.0)	78.75 (4.2)	78.48 (5.01)
Medication (n(%))			
Supplements	41(93.2%)	30(83.3%)	23(85.2%)
Prescription Meds	33(75%)	31(86%)	26(96%)
Psychotrophic Meds	7(16%)	1(3%)	3(11%)
Medical Conditions (n(%))			
No Disease	15(34%)	15(41.7%)	11(40.7%)
Heart Disease	16(36.5%)	12(33.3%)	9(33.3%)
Stroke	0	1(2.8%)	2(7.4%)
Diabetes	0	0	0
Cancer	6(13.6%)	3(8.3%)	1(3.8%)
Disease of the arteries	1(2.3%)	0	0
Pulmonary Disease	0	0	2(7.4%)
Co-Morbidities	6(13.6%)	5(13.9%)	2(7.4%)
Vision			
Corrective eyewear	34(77%)	29(80.6%)	25(92.6%)
Cataracts	5(11.3%)	6(16.7%)	3(11.1%)
Macular Degeneration	2(5%)	0	1(3.7%)
Physical Activity Scores			
(PASE) (mean ± SD)	131.9 (65.17)	123.4 (57.3)	120.9 (76.8)

[1]Note. Medical Conditions and Physical Activity are presented as (**n**: number reporting the condition/activity type within the respective fall group (**%group**: corresponding % within the respective fall group).

Functional Measures

At baseline subjects completed a larger battery of tests as part of a separate study including five gait tests, two leg strength tests, a test of ankle strength, the sit to stand, a stair climb and a lower extremity power test. Subjects were also tested in 6 postural sway conditions. During the observation period, analysis of baseline data identified the tests which best discriminated side-fallers from other-direction fallers (30). This battery represents the first identified risk factors for side falls. At follow-up, subjects were assessed only on those identified measures which included: 1) sway velocity while standing in semi-tandem stance; 2) hip abduction strength; 3) asymmetry in lateral stepping velocity; and 4) tandem walk performance. Though not one of the measures that discriminated side-fallers from other-direction fallers, the Get Up and Go test was also included at follow-up given its utility as a screening tool for fall risk (11). Sway velocity was assessed using the Accu-Sway force platform (Advanced Mechanical Technology, Inc., Watertown, MA). Subjects were asked to stand as still as possible in a semi-tandem position for 20 seconds, first with right foot in front and then the left foot in front. Sway velocity is the average speed of the center of pressure along its path in all directions during the collection period and is measured in cm/second. Hip abduction strength was measured using a hand-held dynamometer (Model 01160, Lafayette Instrument Company, Lafayette, ID, 47904) with subjects completing three maximum isometric trials with each leg and recording the best score in kilograms of force for each side and averaging them. Lateral stepping velocity was calculated from reaction and movement time variables gathered during the Quick Step test (31) which measures reaction time while subjects step to the side as quickly as possible in response to a light stimulus. Subjects performed five trials on each side and velocity asymmetry in cm/second was averaged across the five trials. For the tandem walk test, used to measure dynamic balance and mobility, subjects were required to walk heel-to-toe as fast as possible for 3.05 meters. At every step, the heel of the stepping foot had to make contact with the toe of the stance foot. Subjects performed the test until 2 successful trials were completed. A successful trial was defined as one where the participant covered the entire distance without assistance and had no more than one mis-step. During the Get Up-and-Go, subjects were asked to rise from a seated position, walk forward three meters, turn, and return to a seated position as quickly as possible. The faster of two completed trials was recorded to the nearest 1/100 of a second for both gait tasks.

Reliability

Measures of reliability were obtained from 26 subjects (fallers n=16 and non-fallers n=10) who came back a second time during baseline data collection. Re-testing was conducted within 2 to 5 weeks of the initial session. The demographics (mean $\pm$ standard deviation) for this subset were: age = 78.9 $\pm$ 5.6 y; body mass = 69.8 $\pm$ 12.9 kg; and height = 161.9 $\pm$ 7.6 cm. There were no significant differences between sessions on any of the balance, strength, or mobility measures. Intraclass correlations (ICC) ranged from 0.69 for the manual muscle test to 0.90 for the Get Up and Go. Estimates of single measure ICCs were slightly lower for all tests. The test of non-randomness was conducted for all measures with no significant results.

<u>Statistical Analysis</u>

Less than 3% of the total data set had missing values. These were replaced using an expectation maximization approach in SPSS 10.0 (SPSS Inc., 1998-2000, Chicago, IL). Some degree of positive skew was evident across all groups on most variables. The primary deviation from normality was a significant positive skew, predominant among the non-fallers.

Mathematical transformations were implemented when data violated normality tests. Non-parametric statistics were also run and the results of the non-parametrics, the parametrics on the transformed data, and parametric procedures on the non-transformed data yielded similar results. Thus, the results of the parametric analyses on the non-transformed data are presented. In all correlational analyses, relationships of $r \geq .30$ were considered meaningful. Weaker relationships were determined *a priori* to be practically insignificant regardless of statistical significance. We conducted a 2x3 (time x fall group) doubly multivariate repeated measures analysis to assess changes in side-fall risk variables over the observation period, and to determine whether these changes differed between fall groups. In instances where the assumption of equal variances between groups was violated, we chose Pillai's Trace as our statistic to evaluate the multivariate effect as it is more conservative and more robust to such violations. Significant main effects were followed up with univariate analyses. All univariate and multivariate analyses of variance utilized type III sum of squares to control for unequal sample size. Bonferroni adjustments were implemented to control for experiment-wise error in the univariate repeated measures procedures and all post hoc analyses. Results were considered statistically significant at the $p \leq .05$ level.

RESULTS

Changes Over Time-All Subjects

Our first research question asked whether performances on specific risk factors for side falls change over two years in community-dwelling elderly. We observed a significant decrease in hip abduction strength ($p < .001$) and a decline in tandem walk performance ($p = .031$) over the observation period (Pillai's Trace =.350; $p < .001$) (Table 2.2). Follow-up univariate analyses indicated the change in hip abduction strength occurred in all groups ($p < .001$) and the change in tandem walk performance was attributable to changes within the other-direction fallers only ($p = .034$).We repeated the analysis controlling for age at follow-up and found there were no changes over time on these variables independent of age (Pillai's Trace=.04, $p = .406$).

We calculated the rate of change over two years on these variables using a standard rate calculation $\{[(F_{ollow\text{-}up} / B_{aseline}) - 1] * 100\}$. The two-year rate of change was greatest for the tandem walk, with non-fallers displaying an 18% increase in the time to complete the task, side-fallers showing a 19% increase, and other-direction fallers a 22% increase in the time to complete the task (Table 2.3).

Table 2.2 Baseline and Follow-up Measures (means ± SD)

Variable	Non-fallers n=41		Side-fallers n=36		Other fallers n=27	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Height* (cm)	159.4 (6.2)	159.3 (6.1)	161.1 (6.0)	160.8 (6.2)	161.4 (5.8)	161.1 (5.9)
Weight (kg)	64.6 (11.5)	64.5 (10.8)	64.0 (13.2)	64.4 (13.6)	71.6 (13.6)	71.4 (14.8)
Tandem Walk[*a] (sec)	17.31 (6.9)	19.8 (11.3)	20.7 (11.1)	21.3 (8.9)	17.6 (6.9)	20.9 (10.5)
Get Up & Go[*b] (sec)	7.95(1.4)[b*]	7.99 (1.7)	9.03(2.9)[b*]	9.66 (5.2)	8.66 (2.4)	8.71 (2.7)
Hip Abduction[*ab] (kg)	18.9(4.6)[b*]	16.68(5.3)[b*]	16.31(4.2)[b*]	13.5(4.5)[b*]	17.82(3.8)	14.15(5.3)
Step Asymmetry[b*](cm/s)	14.9(13.9)[b*]	11.61(10.9)	11.21(11.0)	11.01(9.4)	7.25(5.9)[b*]	13.17(10.1)
Sway Velocity (cm/sec)	3.27 (1.19)	2.97 (1.04)	3.51(1.63)	4.77(6.63)	3.52(0.97)	3.33(1.21)

[a] Within subject analyses: *changes over time ($p < .05$).
[b] Between subject analyses; *Non-fallers vs. Side-fallers, ($p<.03$).

Table 2.3 Two-year Rate of Change[1] in Side Fall Risk Variables (mean ± SD)

Variable	Non-fallers n=41	Side-fallers n=36	Other fallers n=27
Height*	-0.093 ±0.44	-0.22 ±0.65	-0.17 ±0.47
Weight	0.13 ±3.27	0.72 ±3.75	-0.52 ±5.09
Tandem walk*	17.86 ±53.53	18.46 ±56.1	22.32 ±45.92
Up and Go	1.56 ±18.54	4.53 ±21.02	0.95 ±15.59
Hip Abduction*	-11.59 ±19.3	-14.57 ±30.21	-20.60 ±25.13
Step Asymmetry	38.3 (138.6)	46.7 (92.9)	164 (378.5)
Sway Velocity	-4.49 ±27.38	6.1 ±23.25	-2.57 ±29.64

[1]Rate of change presented as percent change over two years
*Significant change in these variables ($p < .05$).

Fall Category by Time-All Subjects

Our second question asked whether non-fallers, side-fallers, and other-direction fallers differed in the rate of change in side fall risk variables over two years. We found no group by time interactions, thus there were no differences between groups in the rate of change in these variables (Pillai's Trace=.083, p=.386) This did not change when we controlled for age in the analyses (Pillai's Trace=.083, p=.389).

Differences in Performance on Side Fall Risk Variables by Fall Group

Multivariate repeated measures analyses indicated no significant fall group effect (Pillai's Trace = .112, p=.169) and this effect was not altered when controlling for age in the analysis (Pillai's Trace=.136, p=.081). Univariate analyses of differences between groups at baseline and follow-up controlling for age revealed group differences in baseline Get Up and Go (p=.03), hip abduction strength (p=.03) and step asymmetry (p=.026). Follow-up pairwise comparisons with a Bonferonni adjustment revealed side-fallers had weaker hip abduction strength and were slower on the Get Up and Go compared to non-fallers at baseline (p=.025 and p=.04, respectively). Other direction fallers exhibited considerably less step asymmetry compared to non-fallers (p=.022). At follow-up, only hip abduction strength was different between groups (p=.015). Follow-up pairwise comparisons revealed side-fallers had weaker hip abduction strength than non-fallers at follow-up (p=.019).

DISCUSSION

Our aim was to study two-year changes on side fall risk variables in a sample of community-dwelling women over 70, and to determine whether changes differentiated side-fallers from non-fallers and other-direction fallers. We observed significant decreases in hip abduction strength and tandem walk performance. Though changes in these variables were not evident when we controlled for age, the magnitude of decrement in performance was substantial. Tandem walk performance declined 18%-22% and hip abduction strength declined 12%-20% over the two years.

Our second question asked whether there were differences in the means and patterns of change in side-fall risk variables between fall groups. There were no differences in rates of change, but there were group differences at baseline and follow-up. Side-fallers were slower on the Get Up and Go at baseline and had weaker hip abduction strength, both at baseline and follow-up compared to non-fallers. These differences were independent of age. In addition, other-direction fallers exhibited less step asymmetry compared to non-fallers. However, this was observed at baseline only.

Strengths of this study include the longitudinal design, the measurement of specific side-fall risk variables, the controlled fall surveillance, and the high retention rate over two years. Much of the data on rates of decline in older adults comes from cross-sectional studies, and the majority of data are collected in men. To our knowledge, there are no studies examining differences in rates of change in fall risk factors between side-fallers and non-fallers and there are no studies examining 2-year changes in specific risk factors for side falls. Side falls significantly increase the risk of hip fracture, and thus, identifying changes in variables that discriminate side-fallers from other-direction fallers and non-fallers, may be important for predicting those at the greatest risk of experiencing a fall-related hip fracture. We were able to quantify fall data confidently on 100% of our final sample, and we were able to re-test over 80% of our original sample, all of whom maintained independent living status throughout the study duration.

An important study limitation is the great variability inherent in the older population. A lifetime of different experiences leads to a multitude of factors contributing to function that are difficult to identify and control for. Large standard deviations on most variables are a function of this variability and contribute to low power in the analyses. Though we controlled for disease, physical activity, vision, and medication use, it is possible there are additional important variables we neglected to assess. A second limitation pertains to the lack of previous data regarding the classification of side-fallers. We elected to characterize anyone with at least one side fall as a "side-faller" and it is possible that a single side fall does not pose the same risk as multiple side-falls. In post hoc analyses we teased out multiple side-fallers (n=16) and multiple other-direction fallers (n=11) and found no differences in side-fall risk variables between these two groups. Thus, it is possible that our current classification scheme may be targeting frequent fallers as well as side-fallers though we had too few recurrent fallers to adequately test this hypothesis, particularly considering the population variability. We contend, however, that it only takes one side fall to fracture a hip and thus it is important to learn all we can about this phenomenon. Finally, the lack of a standardized physical activity questionnaire at baseline was a limitation. We collected extensive qualitative and quantitative physical activity data at follow-up, but cannot correlate changes in function to changes in physical activity. In our favor, Hughes et al. (14)

found changes in physical activity patterns were not associated with changes in muscle strength among older adults.

Although there are no published studies examining changes in specific risk factors for side-falls, there are data reporting percentage change on functional performance variables for this population. However, most of the published data on percentage change in older adults comes from cross sectional studies, and there is evidence that reliance upon cross sectional change data may be highly inaccurate (6, 7, 14). Hughes et al. (14), who studied both men and women, aged 46-78 at baseline, for approximately 10 years, found longitudinally measured declines in strength in the knee extensors and flexors were ~ 60% greater than cross sectional measures. In a 12-year longitudinal study examining aging of skeletal muscle, knee extension strength declined ~2%/year at angular velocities of 60°/sec and 2.5%/year at 120°/sec in a group of sedentary men whose mean age at baseline was 65.4 ± 4.2 years (6). These values were twice the reported rates of decline in a cross-sectional study of the same population (7). These data are considerably lower than our reported two-year loss. However, Frontera et al., (1991) averaged across 12 years beginning at age 65 and our data is over two years in a population that was considerably older at baseline, and exclusively female. In a three-year prospective study of women aged 65 and older, performance on the chair stand task, a measure of lower extremity strength and function, declined 21% over three years (23). Both the age and demographic of this study population were much more similar to our own, though they had considerably more subjects (n=1000 women).

Aside from exercise interventions typically less than one year in duration, longitudinal studies on postural sway and dynamic balance in the elderly are scarce. Cross sectional studies report increased amplitude and frequency of postural sway during static balance tasks in older persons compared to younger individuals (1, 15, 19) and older fallers are less able to maintain postural control during semi-tandem stance tasks compared to non-fallers (18). Similarly, tandem walk performance decreases with age and elderly fallers are slower than non-fallers on the tandem walk (11, 19). Our findings reflect those data in that changes in tandem walk performance in our study were influenced by age. However, we did not find differences between groups in tandem walk performance. It is possible that this discrepancy is an issue of gender differences. Both Gunter et al., (2000) and Lord et al. (1999) included men and women in their data sets (11, 19).

Among our sample of independent, community-dwelling women over 70 years, low hip abduction strength dominated side-fall risk. The difference between groups on Get Up and Go Performance was significant at baseline, but not at follow-up, suggesting regression towards the mean on this variable with age, regardless of fall status. By contrast, differences between non-fallers and side-fallers with respect to hip abduction strength became more pronounced at follow-up.

Asymmetry in lateral stepping velocity captures differences between right and left legs in the speed with which individuals can step to the side during a lower extremity reaction time test. Other-direction fallers displayed considerably less asymmetry compared to non-fallers at baseline, but not at follow-up. We have no explanation for this finding, particularly given the large change from baseline to follow-up among the other-direction fallers. However, the data were highly variable, evidenced by standard deviations nearly equal to the mean, and thus, it is difficult to interpret this result with much confidence.

It is conceivable that differences between groups in hip abduction strength and Get Up and Go performance in this study were reflective of physical activity patterns. Although we found no statistical differences in physical activity scores between non-fallers, side-fallers and other-direction fallers, non-fallers reported doing more physical activity, and higher physical activity scores were associated with increased hip abduction strength ($r=.36$, $p<.001$) and better performance on the Get Up and Go ($r=-.35$, $p<.001$). Physical activity was not associated with any of the other risk factors for side falls.

It is not surprising that physical activity was associated with performances on risk factors for side falls. Numerous studies report a relationship between physical activity and functional performance among older individuals (2, 20, 21, 29). However, there are few data specific to Get Up and Go performance and hip abduction strength. In a study of 705 community-dwelling Japanese women aged 55-93, physical activity was independently and positively associated with performance on the Get Up and Go test (4), and lower hip abduction strength was associated with impaired function in a sample of nearly 10,000 women over 65 years from the Study of Osteoporotic Fractures (30).

In summary, we found hip abduction strength and tandem walk performance declined significantly over two-years in community-dwelling women over 70 years of age, though changes in these variables were eclipsed when age was included in the analysis. Side-fallers were weaker and slower on the Get Up and Go compared to non-fallers, but the rate of change on side fall risk variables was similar in all groups. The relationship of physical activity to hip abduction strength and performance on the Get Up and Go highlights the need to develop exercise programs targeting these variables in populations at risk for side falls. In doing so, we can develop risk management programs to effectively reduce side-falls and ultimately hip fractures among elderly women.

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CHAPTER 3

BALANCE SELF-EFFICACY PREDICTS PERFORMANCE ON MOBILITY AND BALANCE-RELATED RISK FACTORS FOR SIDE AND FREQUENT FALLS AMONG COMMUNITY-DWELLING ELDERLY WOMEN OVER 70 YEARS.

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ABSTRACT

Previously, we reported that fallers exhibit lower balance self-efficacy (BSE) than non-fallers. However, individuals who fall to the side are at an increased risk of hip fracture and it is unknown whether BSE differs by fall direction. We assessed BSE over two years in 107 community-dwelling elderly women (mean age 77 ± 4.47 years), compared changes in BSE between non-fallers, side fallers, and other-direction fallers, and assessed the relationship between BSE and risk factors for side falls. Non-fallers had lower BSE at follow-up (153.7 ± 23.7) compared to baseline (149.8 ± 29.8), (p=.013). There were no changes in BSE scores among the side-fallers or the other-direction fallers. Side fallers reported the lowest BSE scores of the 3 groups at baseline and follow-up. There were no differences in the rate of change in BSE between groups. In regression analyses, BSE at baseline had the greatest contribution in the models predicting Get Up and Go and hip abduction strength (p<.001) at follow-up, explaining 28% and 14% of the variance respectively, and was an independent predictor of tandem walk performance (p=.007). Our results suggest the BSE Scale may have utility as a screening tool to identify individuals at a significant risk for side falls.

INTRODUCTION

Despite extensive research, falls incidence in the elderly is increasing, as are fall-related injuries (Stevens, et al, 1999). In the etiology of hip fracture, of particular concern are falls to the side which increase hip fracture risk 6-fold to 20-fold (Greenspan, Myers, Maitland, Resnick, & Hayes, 1994; Hayes et al., 1993). Hip fractures carry significant economic burden, contribute substantially to morbidity and mortality, and carry severe psychological outcomes evidenced by the 80% of women over the age of 75 who report they would rather die than be admitted to a nursing home due to a hip fracture (Salkeld et al., 2000). Despite these astonishing figures, few programs have successfully reduced falls and fracture incidence, and perhaps the most serious of all falls, those to the side, are poorly understood.

In addition to severe physical consequences, falls contribute to an increased fear of falling among older adults (Arfken, Lach, Birge, & Miller, 1994; Maki, Holliday , & Topper, 1991). Fear of falling has been associated with increased falls incidence (Maki, Holliday, & Topper, 1991) and appears to be a psychologically mediated predictor of dependence that is related to physical function (Lachman et al., 1998) but it is unknown how this psychological variable relates to side fall risk.

Fear of falling is typically operationalized in the literature as a continuum of self-confidence in the domains related to falling such as balance (Tinetti, Richman, & Powell, 1990). Research in this area is still novel and studies in community-dwelling populations have used a variety of measures to assess fear of falling. Methods vary from a single question asking participants if they are fearful, to indirect, situational specific balance and falls efficacy scales. Instruments consisting of multiple scaled questions are reputed to be more sensitive to change in fear over time (Velozo and Peterson, 2001). Research is predicated on Bandura's concept of self-efficacy, representing individuals' perceptions of their abilities in specific domains (Bandura, 1977). According to Bandura's theory, individuals' self-perceived capabilities within specific domains determine whether they will engage in particular activities. A person with low self-efficacy as it pertains to controlling their balance while walking down stairs, but average self-efficacy while walking on uneven ground, would tend to avoid stairs, but feel confident walking on uneven ground. For such an individual, the question "Are you afraid of falling?" is insufficient to quantify fear as their fear is situation specific. Furthermore, in older adults, stronger self-efficacy is related to health promoting behaviors and increased physical function (Tinetti, Mendes de Leon, Doucette, & Baker, 1994). Thus, measures of balance self-efficacy may provide a better metric of fall risk than a single question about fear.

We recently completed a study assessing changes in balance self-efficacy (BSE) over one-year in community-dwelling elderly fallers and non-fallers and relating BSE to risk factors for side falls and frequent falls (Gunter et al., in press). We found that fallers exhibited lower BSE scores than non-fallers, and that BSE scores were stable over one year. In addition, balance self-efficacy was predictive of medio-lateral sway and performance on the Get Up and Go and tandem walk. However, in that study we included both men and women and did not examine differences in BSE by fall direction.

Thus, our aims were 1) to examine the two-year change in balance self-efficacy (BSE) among community-dwelling women over 70 years, and to determine whether changes differed between individuals who fell to the side during the two-year observation period, compared to non-fallers and other directions fallers, and 2) to determine if BSE scores at baseline were predictive of mobility and balance-related side-fall risk factors at follow-up. We assessed changes in BSE using the Balance Self-Efficacy Scale and we measured the rate of change in sway velocity, hip abduction strength, lateral stepping velocity, tandem walk and Get Up and Go performances and assessed the relationship of these variables to BSE scores. We hypothesized that BSE would remain stable over the two years, and that BSE would be predictive of performance on side-fall risk variables at follow-up.

METHODS

Design

This was a two-year prospective study conducted between November 1998 and November 2001 by the Bone Research Laboratory, Oregon State University, Corvallis, Oregon. All participants resided in the Mid-Willamette Valley in western Oregon. This study was approved by the Oregon State University Institutional

Review Board and all subjects gave written informed consent prior to participation. This study was ancillary to a larger study and participants were recruited from a falls surveillance database. Subjects entered into this study on a rolling basis and returned for follow-up testing two years after their initial test session. Falls surveillance was conducted between baseline and follow-up testing, and participants were categorized by fall status at follow-up.

Subjects

We recruited one hundred twenty-nine women, including fallers and non-fallers, from our fall surveillance database, who had also been tested on a collection of functional measures between November 1998 and November 1999 as part of a case-control study to identify performance variables specific to side-fall risk. Two years later, 107 women, aged 72-93 years (mean $\pm$ *SD*, 76.97 $\pm$ 4.47) returned to the Bone Research Laboratory and were re-tested on the variables specific to side-fall risk. Of the 22 individuals that did not return for follow-up, four had undergone surgery and could not come in for testing within three months of the follow-up date, one developed cataracts, one had a stroke, three moved out of state, another was caring for an invalid husband, one could not get transportation, four were lost to follow-up, and the remaining seven did not wish to participate. Participants were excluded from analyses if they could not complete testing independently without assistance. Two subjects did not meet the inclusion criteria, and a third subject was excluded because she experienced a hip fracture late in the observation period and was bedridden for much of the time prior to follow-up testing. Thus, analyses were performed on data from 104 subjects.

Falls surveillance data were collected quarterly over the two-year observation period. These revealed 192 falls, among 63 women, occurred between baseline and follow-up. Forty-one participants were non-fallers, 36 were side fallers, and 27 individuals fell in directions other than to the side (other-direction fallers). There were no differences in age, height, or weight between groups (Table 3.1).

Participants completed extensive health history and physical activity questionnaires, and were screened for medication use. There were no differences between fall groups with respect to medication use, presence of disease, vision, or reported physical activity (Table 3.1).

Balance Self-Efficacy

Balance self-efficacy was assessed using the Balance Self-Efficacy Scale (BSE) developed at Oregon State University specifically to study balance self-efficacy as it relates to falls in older adults who are likely to be active and display minimal problems with physical functioning. In a pilot study the Falls Efficacy Scale (FES) and the Activities-specific Balance Confidence (ABC) scale (Powell & Myers, 1995) did not allow for adequate variability in scores for our robust, physically

Table 3.1 Subject Characteristics by Group (means ± SD)[1]*

Variable	Non-fallers n=41	Side-fallers n =36	Other fallers n=27
Age (mean ± SD)			
Baseline	76.9 (4.0)	76.83 (4.25)	76.56 (4.82)
Follow-Up	78.66 (4.0)	78.75 (4.2)	78.48 (5.01)
Medication (n(%))			
Supplements	41(93.2%)	30(83.3%)	23(85.2%)
Prescription Meds	33(75%)	31(86%)	26(96%)
Psychotrophic Meds	7(16%)	1(3%)	3(11%)
Medical Conditions (n(%))			
No Disease	15(34%)	15(41.7%)	11(40.7%)
Heart Disease	16(36.5%)	12(33.3%)	9(33.3%)
Stroke	0	1(2.8%)	2(7.4%)
Diabetes	0	0	0
Cancer	6(13.6%)	3(8.3%)	1(3.8%)
Disease of the arteries	1(2.3%)	0	0
Pulmonary Disease	0	0	2(7.4%)
Co-Morbidities	6(13.6%)	5(13.9%)	2(7.4%)
Vision			
Corrective eyewear	34(77%)	29(80.6%)	25(92.6%)
Cataracts	5(11.3%)	6(16.7%)	3(11.1%)
Macular Degeneration	2(5%)	0	1(3.7%)
Physical Activity Scores (PASE) (mean ± SD)	131.9 (65.17)	123.4 (57.3)	120.9 (76.8)

[1]Note. Medical Conditions and Physical Activity are presented as (**n**: number reporting the condition/activity type within the respective fall group (**%group**: corresponding % within the respective fall group)
*No group differences on any variables

active elderly population and did not distinguish between fallers and non-fallers. In our pilot study, 14 of 15 women scored 100% on the FES, and in discussions about the two scales, participants reported that questions did not adequately address tasks they routinely engage in. Thus, we used the BSE Scale which was developed to assess balance confidence in performing more difficult tasks than the FES and ABC scales. The BSE Scale was adapted from the ABC Scale (Powell & Myers, 1995) and consists of 18 questions asking respondents to rate the proportion of time they feel confident engaging in a particular task (I feel confident 0% of the time– I feel confident 100% of the time). Two domains comprise the total BSE Scale. We refer to these domains as *Assisted* and *Unassisted.* Questions 1, 3, 5, 6, 8, 10, 12, 14, 16, 18 are specific to the Assisted domain and queries subjects about their confidence on tasks in which there is some form of assistance (e.g. handrails, walkers, canes, or a helper to assist). A sample question from this domain asks:

1. How confident are you that you can walk across uneven ground **with assistance** at night without losing your balance?

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Questions 2, 4, 7, 9, 11, 13, 15, 17 inquire about tasks where no assistance is assumed (*Unassisted*). These tasks require greater confidence and independence than those is the Assisted domain. A sample question from this domain asks:

2. How confident are you that you can stand on one leg **with no additional support** while putting on a pair of trousers, without losing your balance?

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

We assessed internal consistency of the Balance Self-Efficacy Scale (BSE) in a sample of 165 community-dwelling, generally active, older adults (134 women; 31 men; mean age 77.5 ± 5.2). Using split-half reliability we observed a

Spearman-Brown corrected correlation of .96, whereas Cronbach's produced an alpha of .95. Evidence for convergent and discriminant validity was given by correlating the Balance Self-efficacy scale with the ABC scale (convergent validity) and the Falls Efficacy Scale (discriminant validity). Fifteen independently-dwelling elderly women from our pilot study (mean age 74 $\pm$ 5.4) completed both scales. As expected, the BSE was highly related to the ABC scale ($r=.95$, $p<.001$) and moderately associated with the FES ($r=.53$, $p=.114$). Test re-test reliability was assessed by having the same women complete the Balance Self-efficacy Scale twice, approximately two weeks apart. The intraclass correlation was 0.89 and the single measure intraclass correlation was slightly lower at 0.81.

Functional Measures

In a recent case-control study, we developed the Side Fall Risk Index (SFRI), a battery of tests to identify elderly fallers at risk for falls to the side (White, Gunter, Hayes, & Snow, 2001). At baseline and at follow-up, subjects in the present study were examined on the components of the SFRI and on the Get Up and Go. The Get Up and Go is not part of the SFRI, but was included as an additional measure of mobility given its proven utility as a screening tool for fall risk (Gunter, White, Hayes, Snow, 2000; Okumiya et al., 1996). In the SFRI, tests included: 1) sway velocity while standing in semi-tandem stance, 2) hip abduction strength, 3) asymmetry in lateral stepping velocity, 4) tandem walk performance. Sway velocity was assessed using the Accu-Sway force platform (Advanced

Mechanical Technology, Inc., Watertown, MA). Subjects were asked to stand as still as possible in a semi-tandem position for 20 seconds, first with right foot in front and then the left foot in front. Sway velocity is the magnitude of sway over time and is measured in cm/second. Hip abduction strength was measured using a hand-held dynamometer (Model 01160, Lafayette Instrument Company, Lafayette, ID, 47904) with subjects completing three maximum isometric trials with each leg and recording the best score in kilograms for each side and averaging the two sides. Lateral stepping velocity was calculated from reaction and movement time variables gathered during the Quick Step test (White, Gunter & Snow, in press) which measures reaction time while subjects step to the side as quickly as possible in response to a lighted stimulus. Subjects performed five trials on each side and velocity asymmetry in cm/second was averaged across the five trials. For the tandem walk test, used to measure dynamic balance and mobility, subjects were required to walk heel-to-toe as fast as possible for 3.05 meters. At every step, the heel of the stepping foot had to make contact with the toe of the stance foot. Subjects performed the test until 2 successful trials were completed. A successful trial was defined as one where the participant covered the entire distance without assistance and had no more than one mis-step. The faster of the two complete trials was recorded to the nearest 1/100 of a second. During the Timed Get Up-and-Go, subjects were asked to rise from a seated position, walk forward three meters, turn, and return to a seated position as quickly as possible. The faster of two completed trials was recorded to the nearest 1/100 of a second.

Falls Surveillance

Frequency of falls and fall characteristics were determined from falls surveillance using falls diaries, postcard mailings, and follow-up phone contacts. All participants received fall diaries upon entrance into the fall surveillance study between January of 1998 and April of 1999, and were issued new falls diaries each year. Individuals kept a record of their falls in their diaries and were mailed postcards every three months, upon which they indicated whether or not they experienced a fall during the three-month period. If a fall was indicated on the returned postcard, participants were called and questioned as to the characteristics of those falls using a detailed questionnaire. A fall was defined as "an event that results in a person coming to rest unintentionally on the ground or other lower level" (Tinetti, Speechley & Ginter, 1988). A side fall was defined as any fall in the sideways direction terminating with impact on the hip or side. Falls resulting from an externally applied force (such as being struck by a cyclist or an automobile) were not recorded.

Reliability

Reliability over all functional measures was conducted on 26 subjects (fallers n=16 and non-fallers n=10) who came back a second time during baseline data collection. Re-testing was conducted within 2 to 5 weeks of the initial session. The demographics (mean ± standard deviation) for this subset were: age = 78.9 ± 5.6 y; body mass = 69.8 ± 12.9 kg; and height = 161.9 ±7.6 cm. There were no significant differences in scores on any of the balance, strength, or mobility measures between sessions. Intraclass correlations (ICC) ranged from 0.69 for the manual muscle test to 0.90 for the Get Up and Go. Estimates of single measure ICCs were slightly lower for all tests. The test of non-randomness was conducted for all measures with no significant results.

Statistical Analysis

Less than 3% of the total data set had missing values that were replaced using an expectation maximization approach in SPSS 10.0 (SPSS Inc., 1998-2000, Chicago, IL). This is an iterative procedure that computes the expected value of the complete data log likelihood and substitutes expected values for missing data and maximizes the likelihood function to obtain new parameter estimates. Some degree of positive skew was evident across groups on most variables. The primary deviation from normality was a significant positive skew on the functional variables, predominant among the non-fallers.

Mathematical transformations were conducted and implemented when data violated both the Kolmogorov-Smirnov and Shapiro-Wilk normality tests. Non-parametric statistics were also run and the results of the non-parametrics, the parametrics on the transformed data, and parametric procedures on the non-transformed data yielded similar results. Thus, the results of the parametric analyses on the non-transformed data are presented. We conducted 2x3 (time x fall group repeated measures analyses of covariance to assess changes in BSE over the observation period and to determine whether these changes differentiated side fallers from non-fallers and other direction fallers. Because fear of falling is related to both age and physical function (Lawrence et al., 1998) and because, in our sample, age and physical activity correlated with BSE at follow-up ($r=-.44$ and $r=.34$, $p<.001$ respectively) we entered both age and physical activity score as covariates in all repeated measures models. In instances where the assumption of equal variances between groups was violated, we chose Pillai's Trace as our statistic to evaluate the multivariate effect as it is more robust to such violations. Wilk's Lambda was used for analyses where this assumption was not violated. Significant main effects were followed up with univariate analyses. Bonferroni adjustments were implemented to control for experiment-wise error in the univariate repeated measures procedures and all post hoc analyses. Analysis of variance was used to assess differences in reported physical activity scores by age and fall categories at follow-up. All analyses of variance utilized type III sum of squares to control for unequal sample size.

In correlational analyses, only relationships of $r\leq.30$ were reported as meaningful. Weaker relationships ($r<.30$) were determined *a priori* to be practically insignificant regardless of statistical significance. Stepwise regressions were run with follow-up Get Up and Go, tandem walk, sway velocity, hip abduction strength, and asymmetry in lateral stepping velocity as dependent variables. Baseline age, height, weight, medication use, disease status and BSE scores were entered as predictor variables. Baseline hip strength was included in the regressions for which follow-up hip strength was not the outcome variable given the significant contribution of lower extremity strength to measures of functional mobility (Chandler, Duncan, Kochersberger, & Studenski, 1998). Results were considered statistically significant at the $p \leq .05$ level.

RESULTS

Balance Self-Efficacy

Our first research question asked whether balance self-efficacy (BSE) changed over two years in community-dwelling elderly women and whether BSE was different between fall groups. With age and physical activity score (PASE) entered into the repeated measures model we found a significant change in BSE over the two years (Wilk's $\Delta = .960$, p=.04) (Table 3.2). Follow-up univariate analyses within each fall group indicated the main effect was due to the non-fallers, whose BSE decreased –2.5% over the 2 years (p=.01). There were no changes in the BSE scores of side-fallers (p=.09) or other-direction fallers (p=.371) over the 2 years. We also analyzed the Assisted and Unassisted domains independently, and found that scores on questions in the Assisted domain changed over 2 years (Wilk's $\Delta = .958$, p=.039) (Table 3.2). Follow-up univariate analyses revealed that the main effect was again due to the non-fallers whose Assisted Domain scores decreased –1.3% (p=.001) There were no changes in scores on the Assisted domain among side-fallers and other-direction fallers (p=.166 and p=.284, respectively). Scores pertaining to questions in the Unassisted domain did not change significantly over the 2 years for any group (Wilk's $\Delta = .975$, p=.113).

Between group analyses revealed no differences in BSE by fall group (p=.396). Nor were there differences between fall groups when BSE scores were analyzed by domain (Assisted domain, p=.610; Unassisted domain, p=.296).

Table 3.2 Baseline and Follow-up Balance Self-Efficacy Scores (means ± SD)

Variable	Non-fallers n=41		Side-fallers n=36		Other fallers n=27	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Total BSE*	153.7(23.7)	149.8(29.8)	143.4(32.4)	142.9(33.6)	148.3(27.5)	150.9 (29)
Assisted* Domain	91.5 (10.8)	90.3 (13.4)	86.9 (15.4)	89.0 (14.1)	88.9 (12.6)	90.9 (13)
Unassisted Domain	62.2 (13.8)	59.5 (17.7)	56.6 (18.3)	53.9 (20.6)	59.3 (16.1)	60.0 (17.1)

*Significant changes over 2 years ($p < .05$)

BSE as a Predictor of Function at Follow-up

Our second research question asked whether BSE at baseline was predictive of mobility and balance-related side-fall risk factors at follow-up. BSE had the greatest contribution in the models predicting Get Up and Go and hip abduction strength ($p<.001$) explaining 28% and 14% of the variance respectively (Table 3.3). BSE was also an independent predictor of tandem walk performance, though age contributed more to the model ($p<.001$) (Table 3.3). There was no relationship between BSE and sway velocity or asymmetry in stepping velocity. Table 3.4 contains functional data at baseline and follow-up.

Table 3.3 Summary of Regression Models

Variables in Model to Predict Get Up and Go	**R**	**R Square Change**	**Std. Error of Estimate**	**Sig. F Change**
Baseline BSE score	.531	.281	3.02	.000
BSE, Age	.624	.108	2.81	.000
BSE, Age, Hip Strength	.643	.024	2.75	.045
Variables in Model to Predict Hip Strength				
Baseline BSE score	.376	.141	4.83	.000
BSE, Ht.	.529	.033	4.76	.047
Variables in Model to Predict Tandem Walk				
Baseline Age	.386	.15	9.51	.000
Baseline BSE score, Age	.456	.058	9.22	.007

Table 3.4 Baseline and Follow-up Measures (means ± SD)

Variable	Non-fallers n=41		Side-fallers n=36		Other fallers n=27	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Height* (cm)	159.4 (6.2)	159.3 (6.1)	161.1 (6.0)	160.8 (6.2)	161.4 (5.8)	161.1 (5.9)
Weight (kg)	64.6 (11.5)	64.5 (10.8)	64.0 (13.2)	64.4 (13.6)	71.6 (13.6)	71.4 (14.8)
Tandem Walk [*a] (sec)	17.31 (6.9)	19.8 (11.3)	20.7 (11.1)	21.3 (8.9)	17.6 (6.9)	20.9 (10.5)
Get Up & Go [*b] (sec)	7.95(1.4) [b*]	7.99 (1.7)	9.03(2.9)[b*]	9.66 (5.2)	8.66 (2.4)	8.71 (2.7)
Hip Abduction [*ab] (kg)	18.9(4.6) [b*]	16.68(5.3)[b*]	16.31(4.2)[b*]	13.5(4.5) [b*]	17.82(3.8)	14.15(5.3)
Step Asymmetry[b*](cm/s)	14.9(13.9)[b*]	11.61(10.9)	11.21(11.0)	11.01(9.4)	7.25(5.9) [b*]	13.17(10.1)
Sway Velocity (cm/sec)	3.27 (1.19)	2.97 (1.04)	3.51(1.63)	4.77(6.63)	3.52(0.97)	3.33(1.21)

[a] Within subject analyses: *changes over time ($p < .05$).
[b] Between subject analyses; *Non-fallers vs. Side-fallers, ($p<.03$).

Post hoc partial correlations controlling for age were also run between BSE and function at baseline and follow-up to better understand the relationships between these variables. Partial correlations were run within each group separately (Table 3.5). At baseline, BSE was associated with Get Up and Go in the non-fallers ($r=-.33$, $p=.035$) and the side-fallers ($r=-.42$, $p=.012$). BSE was also associated with sway velocity among the non-fallers at baseline ($r=-.41$, $p=.009$). There were no significant relationships between function and BSE among the other-directions fallers at baseline. At follow-up BSE was related to tandem walk ($r=-.49$, $p=.001$) among the non-fallers only. Get Up and Go was associated with BSE at follow-up among the non-fallers ($r=-.51$, $p=.001$) and the side-fallers ($r=-.65$, $p<.001$). Hip abduction strength was associated with BSE among the non-fallers ($r=.37$, $p=.020$) and the side-fallers ($r=.39$, $p=.036$). There were no relationships at follow-up between BSE and function among the other-direction fallers.

Table 3.5 Correlations Among Side-Fall Risk Variables Controlling for Age at Baseline and Follow-up

Variable	Fall Group	Tandem walk	Get Up and Go	Hip Abd. Strength	Sway Velocity	Step Asymmetry
Baseline **Total BSE**	Non-fallers (n=44)	-.19 (p=.237)	**-.33 (p=.035)***	.18 (p=.258)	**-.41 (p=.009)***	.05 (p=.646)
	Side-fallers (n=36)	-.17 (p=.337)	**-.42 (p=.012)***	.30 (p=.077)	-.13 (p=.446)	-.05 (p=.758)
	Other-fallers (n=27)	-.27 (p=.181)	-.27 (p=.188)	.14 (p=.487)	-.14 (p=.484)	-.22 (p=.281)
Follow-up **Total BSE**	Non-fallers (n=44)	**-.49 (p=.001)***	**-.51 (p=.001)***	**.37 (p=.020)***	-.09 (p=.572)	.03 (p=.876)
	Side-fallers (n=36)	-.11 (p=.510)	**-.65 (p<.001)***	**.36 (p=.036)***	-.07 (p=.710)	.19 (p=.281)
	Other-fallers (n=27)	-.11 (p=.598)	-.34 (p=.087)	**.38 (p=.053)***	.04 (p=.844)	-.11 (p=.586)

* p<.05

DISCUSSION

Our first research question addressed the 2-year change in balance self-efficacy scores and assessed differences in BSE between fall groups. Overall, there was a decline in BSE that was attributable to the non-fallers in our study. Non-fallers exhibited a 2.5% decline in total BSE scores between baseline and follow-up, compared to no measurable change within the fall groups. We found no differences in the rate of change in BSE scores between groups. However, the side fallers reported the lowest BSE scores at baseline and follow-up.

Our second research question asked whether BSE at baseline was predictive of function at follow-up. We found BSE was significantly associated with function and had the greatest contribution in the models predicting Get Up and Go and hip abduction strength. BSE explained 28% of the variance in Get Up and Go performance and 14% of the variance in hip abduction strength. BSE was also an independent predictor of tandem walk performance.

Strengths of this study include the longitudinal design, the controlled falls surveillance, and the high retention rate over a two-year period. Furthermore, this is the first report examining balance self-efficacy and the relationship of this psychological variable to risk factors specific to side and frequent falls within a population of known side-fallers, non-fallers, and other-direction fallers. We also included functional data at baseline and at follow-up enabling us to correlate changes in BSE to changes in function.

The primary weakness of this study is the limited external validity and reliability data on the BSE Scale. We used a small sample of 15 women to assess the external validity and reliability of the BSE Scale, and thus the results of these analyses are not broadly generalizable. However, our validity sample did not differ significantly from a random sample of our own subjects, and thus we are confident that the scale was appropriate for our study population. However, a larger sample may have enabled us to capture more side and frequent fallers thereby improving power in the analyses.

That BSE changed over two years was somewhat of a surprise to us as we previously reported balance self-efficacy remained stable over one year in this population (Gunter et al, in press). However, our prior study included a cohort of 29 men and our current sample does not include men. The most interesting finding regarding the two-year change data is that the decline in BSE is attributable to the highest functioning group as it pertains to their scores on questions in the Assisted Domain. It is important to point out however, that although statistically significant, further studies are warranted to determine whether a 2% change in BSE over two years is of practical significance.

The scores from the Assisted Domain reflect individuals' perceptions of confidence during tasks where assistance is available (e.g., walking across uneven ground with the benefit of a companion's arm, or while using a walker). Thus, these tasks are considered easier tasks. It appears only the non-fallers perceived these tasks were more difficult at follow-up than they did at baseline. We hypothesize that the non-fallers, who were the highest functioning group at baseline, surpassed a theoretical "functional threshold" over the 2-year observation period that may have significantly influenced their balance self-efficacy. It is possible that the side-fallers and likely, the other-direction fallers, may have already transitioned through this functional threshold at baseline. Thus, over the 2-year observation period the fallers adjusted their theoretical "set point", adapted strategies to help them perform tasks more easily, and subsequently began to feel more confident during balance-related tasks.

It is important to recognize this "set-point" theory is speculation and further longitudinal research is necessary to examine the theory and develop a hypothesis for testing. However, to better understand what was occurring with respect to these data, we ran correlations between BSE and functional variables at baseline and follow-up (Table 3.5). Among the non-fallers only, an increased time to complete the tandem walk was associated with a decrease in BSE at follow-up. There was no relationship between BSE and tandem walk within the other two fall groups. These findings suggest that among the non-fallers, the only group to significantly decline in BSE, changes in BSE may have been brought about by changes in dynamic balance. Others have shown that older adults transitioning to frailty exhibit lower Activities-Specific Balance Confidence compared to frail or vigorous elderly populations (Kressig et al., 2001). We did not define our population relative to frailty status. Nevertheless there does appear to be a recognizable phenomenon supporting at least the notion that older adults whose functional status is "transitioning" may be more psychologically affected by functional changes than individuals classified as vigorous or frail.

Self-efficacy, as defined by Bandura, is domain specific and sensitive to changes in context (Bandura, 1977). Thus, we expect balance self-efficacy to remain stable in the absence of a stimulus to improve balance, such as exercise, or to decrease balance, such as a dramatic change in health status. There were no changes in disease status from baseline to follow-up for this population. Intuitively, one might suspect that a fall over the observation period is sufficient stimulus to influence BSE scores. However, we did not have complete falls data on the 12 months prior to this observation period, and thus cannot determine whether the falls incidence from our observation year is significantly different from previous years. However, we do have data on functional changes from baseline to follow-up (Gunter, Hayes, & Snow, 2002). And although there were no marked changes in health status, there were significant declines in hip abduction strength as well as a 17%-22% decrease in tandem walk performance. Despite the lack of a relationship between BSE and functional change scores, correlational data support the relationship of function to BSE at baseline and follow-up, independent of age (Table 3.5).

We found that baseline BSE scores were predictive of performance on the Get Up and Go as well as hip abduction strength at follow-up. In our previous study we also found that BSE was predictive of function. However, those data were all taken at the same time point. Thus, that BSE predicted function 2 years down the road in this study lends additional support to the importance of considering psychological variables when evaluating fall risk. To date, the relationship between changes in specific risk factors for side falls and frequent falls and changes in balance self-efficacy is poorly understood. Cumming, Salkeld, Thomas & Szonyi (2000) found that individuals with poor fall self-efficacy at baseline had significant declines in their ability to perform activities of daily living one-year later and these performance changes were more highly correlated with fear than they were with falls incidence. Furthermore, a Tai Chi intervention significantly improved both self-efficacy and physical function in a population of healthy, physically inactive older adults (mean age=72.8 ± 5.1 years) (Li F, Harmer P, McAuley E, Fisher KJ, Duncan TE, & Duncan SC, 2001). In our study, BSE at baseline was predictive of functional performance on specific risk factors for side and frequent falls 2 years later. Thus, increasing balance self-efficacy may be an efficacious strategy to reduce side and frequent fall-risk in this population.

Our results suggest that BSE is associated with functional risk factors for side falls and frequent falls, and that the relationships between psychological and functional risk factors for side falls and frequent falls are complex and differ with respect to fall status. Future prospective studies are necessary to determine if fall status or functional transitions have a more profound effect on balance self-efficacy, or, vice-versa. Finally, the Balance Self-Efficacy Scale may have utility in a clinical setting as a screening tool to identify individuals at a significant risk for injurious falls.

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CHAPTER 4

BONE RESPONSE TO TIMING AND DURATION OF HORMONE REPLACEMENT THERAPY IN WOMEN OVER 70 YEARS.

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ABSTRACT

Objective: Hormone replacement therapy (HRT) is widely prescribed to postmenopausal women for bone loss and few data examine the bone response to the timing of HRT use in older postmenopausal women. Furthermore, differences in bone mineral density (BMD) of the vertebral anterior bodies according to HRT is poorly understood. Our aim was to assess BMD of the hip, anterior-posterior (AP), and lateral spine across levels of HRT use in healthy women over 70 years.

Design: We measured total hip BMD at baseline and after 3 years in 87 older women (72-90 yrs) with distinct HRT profiles: 1) no history of hormone use (**NoHRT**); 2) HRT continually since menopause (**Continual**); 3) HRT begun 10 years after menopause (**Late**); and 4) HRT initiated within the previous 5 years (**New**), and compared the change in BMD of the hip across HRT groups. At follow-up (year 3), we also assessed BMD of the spine in both the lateral and anterior-posterior (AP) projections in a sub-sample of participants (n=48).

Results: Over three years, only the NoHRT group lost total hip BMD (-1.9% ± .72%) (mean ± SE), and this change was significantly different from zero. At the spine, long-term HRT users had higher lateral spine BMD than women who had never been on HRT, but AP BMD was not different between groups. Furthermore, AP T-scores were significantly higher than lateral T-scores in 3 of the 4 groups.

Conclusion: In older women, HRT use prevents bone loss at the hip regardless of timing or duration of use. Results at the spine suggest that AP BMD is inflated in older women and should not be used to diagnose spinal osteoporosis in this population.

Key Words: Osteoporosis, hip BMD, lateral spine DXA

INTRODUCTION

Estrogen replacement therapy (ERT) and hormone replacement therapy (HRT) have been used for over 60 years to preserve bone mineral density (BMD) and to treat menopausal symptoms in postmenopausal women (1). And though it is well established that hormones are effective in reducing bone loss associated with menopause (2-5), the decision to use replacement therapy is a complex dilemma for postmenopausal women. Data from the Study of Osteoporotic Fractures indicate that hormone replacement therapy should be initiated within 5 years of menopause for optimal prevention of fractures (6). However, more recent data indicate that women who begin HRT after age 60 have BMD similar to those who initiated therapy before age 60 (3).

Long term duration of estrogen use has been associated with the development of certain cancers (7) and later initiation of therapy may lower the risk of such health-related consequences of estrogen use. The addition of progestin to estrogen (HRT) has been shown to reduce the risk of these cancers (24) and there is evidence to suggest that recent estrogen use may be protective against the development of other cancers (8). While later initiation on HRT may reduce health consequences associated with long-term use, there are few data that look at the effect late initiation of HRT has on BMD in older women.

Recently, two studies have examined the timing of replacement therapy on bone loss and response to treatment (9, 10). Cauley et al. (2001) studied a population of women 65 and older and found that early initiation of HRT (before age 60) was associated with a reduction in the risk of non-spine fractures if therapy was initiated within 2 years of menopause and continued long-term (9). In addition, women who began therapy an average of 20 years past menopause, and who continued HRT for an average of 10 years tended to have fewer non-spine fractures than individuals who had initiated estrogen within 5 years of menopause, but later discontinued use. Bjarnesen et al. (2002) reported that women closer to menopause experienced a greater rate of bone loss that declined with increasing years past menopause, but the response to therapy was independent of years since menopause (10). However, the average age of the population was relatively young (56.1 ± 4.2 years). Thus the effect of varying the timing of estrogen replacement therapy across a sample of older women is unclear from their work. Furthermore, there have been no studies examining the timing of HRT on spine BMD assessed in the lateral projection.

Anterior-posterior (AP) assessments of the lumbar spine region may have very little value in monitoring bone loss in women more than 10 years past menopause (10). Spine BMD measured in the lateral projection isolates the primary site of spine fractures, the vertebral bodies, from the primarily cortical posterior spinal elements and is less affected by age-related artifacts than spine BMD measured in the AP projection (11, 12). Furthermore, lateral DXA scanning has been shown to be more sensitive to age-related bone loss than AP scanning in women (13, 14) and in men (15). However, to our knowledge, there are no studies examining differences in laterally-derived BMD by the timing of estrogen replacement strategy. Since vertebral fractures occur in the anterior bodies, this assessment may be the most predictive of fractures and most appropriate for assessing the efficacy of HRT.

Our aim in the present study was to 1) examine longitudinally the bone response at the hip to timing and duration of HRT, and 2) to assess BMD of the lateral spine in a sample of older women aged 72-90 years. We identified four patterns of estrogen use among the women in our sample. These patterns included: women who had never used any form of HRT (**NoHRT**); women who had been on HRT continually since menopause (**Continual**); women who initiated HRT at least 10 years post menopause; but had been on HRT for at least 6 years (**Late**); women who had initiated HRT within the previous 5 years (**New**). Specifically we asked the following questions: 1) Does BMD and the rate of change in BMD at the hip differ across patterns of estrogen use in women over 70 years of age, and 2) Is there a difference in BMD of the lateral spine across patterns of estrogen use in women over 70 years of age? We hypothesized that regardless of timing or duration, HRT use would prevent bone loss and result in higher lateral spine BMD in our population of older postmenopausal women.

METHODS

Design

This was a longitudinal, observational study examining three-year changes in BMD at the hip within a population of community-dwelling elderly women over 70 years of age. In addition, we examined BMD of the spine in the AP and lateral projections at follow-up in a sub-sample of our population.

Subjects

All women were participants in a longitudinal falls surveillance study that took place at the Bone Research Laboratory at Oregon State University between November 1997 and November 2001. We recruited 129 women who had received hip scans as part of the fall surveillance study and asked them to return to the Bone Research Laboratory in order for us to examine BMD longitudinally. One-hundred seven women returned for follow-up testing 3 years later. Of the twenty-two individuals that did not return for follow-up, 4 had undergone surgery and could not come in for testing within three months of the 2-year follow-up date, 1 developed cataracts, 1 had a stroke, 3 moved out of state, another was caring for an invalid husband, 1 could not get transportation and lived too far for us to transport, 4 were lost to follow-up, and the remaining 7 did not wish to participate. Participants completed extensive health history questionnaires and were screened for medication use, and osteoporosis risk at baseline and follow-up and physical activity and nutrition questionnaires at follow-up only. All participants resided in the Mid-Willamette Valley in western Oregon. This study was approved by the Oregon State University Institutional Review Board and all subjects gave written informed consent prior to participation.

Hormone Replacement Therapy

Information on estrogen, progestin, calcitonin, SERM, and alendronate use was obtained from each participant at baseline and three years later. Data were collected pertaining to age of treatment initiation, duration of use, and treatment type. Only estrogen and estrogen+progestin users were included, and for the purpose of this investigation, estrogen and estrogen+progestin use were categorized as hormone replacement therapy.

Of the 107 women who returned at follow-up, 10 were excluded because they were being treated with alendronate, and 6 were excluded for use of SERMs. Three women were excluded because they had been on HRT for a number of years but subsequently terminated use and another woman was excluded because she was on Miacalcin. Thus 87 women were included in the analysis for bone loss; 41 who had never used any form of HRT and 46 who had been on HRT for at least 1 full year. Among HRT users, nine women were taking unopposed estrogen and thirty-seven were using estrogen in combination with progestin. There were no differences between estrogen and combination users with respect to age, height, weight or initial BMD at any site. Furthermore, the distribution of estrogen and combination users was similar across HRT groups. Thus we were comfortable combining estrogen and estrogen + progestin users for this study, particularly as our outcomes were all bone-related and there appears to be no difference in the bone effect between these two types of therapies (25).

Bone Mineral Density

At baseline, bone mineral density (BMD: g/cm^2) of the left proximal femur was assessed by dual-energy x-ray absorptiometry (DXA) (Hologic QDR 1000-W, software version 4.74). During the interim between baseline and follow-up, our laboratory upgraded to the QDR 4500-A, software version 9.80D, and thus, all follow-up scans were conducted on the new machine. BMD of the total hip, our primary outcome variable, has an in-house measurement error of approximately 1% on both the 1000-W and the 4500-A in a population similar to those in our study. Data from Hologic (Hologic Inc, Waltham, MA) report there are no differences in the precision error between the two machines (16). We also conducted a validity study between the two machines and performed hip scans on nine individuals over two days on both the QDR 1000-W and the QDR 4500-A. From these data the single measure intraclass correlation between instruments was .97 at the total hip. To further assess the agreement between the two machines we used a Bland-Altman procedure to plot the difference scores, calculated by subtracting BMD as measured by the QDR 4500-A from BMD as measured by the QDR 1000-W, against the mean BMD as measured by the two machines. The limits of agreement, which reflect the 95% confidence interval around the mean difference between the two machines, or 2 standard deviations above and below the mean difference were (–0.05 – 0.07). These data indicate that these two procedures are in fairly good agreement, and that data from the QDR 4500A are neither consistently higher or lower but may provide BMD values 0.05 below to 0.07 above those of the 1000-W. At follow-up, BMD of the lumbar spine and BMD of the lumbar vertebral bodies were assessed by DXA using the Hologic QDR 4500-A. The long term instrument stability of both the QDR 1000-W and the QDR 4500-A were determined by scanning a tissue-equivalent spine phantom daily.

Other Measures

Height and weight were measured with shoes off using the same stadiometer and digital scale at baseline and follow-up. Using these data we calculated body mass index (BMI kg/m^2). Health status, medication use, reproductive history, alcohol consumption, and smoking history were assessed by questionnaire that was reviewed with each participant. Physical activity was assessed using the Physical Activity Scale for the Elderly (PASE) (New England Research Institute, Inc., Watertown, MA). Dietary calcium intake was assessed using the 2000 Brief Block Food Questionnaire (Block Dietary Data Systems, Berkeley, CA). Total calcium intake included dietary and supplemental calcium.

Statistical Analyses

BMD percent change scores at the total hip, and BMD of the spine in the lateral and AP projections were assessed across patterns of HRT use by analysis of covariance (ANCOVA) as were all subject characteristics that were continuous variables. Categorical variables were compared across groups using χ^2. Analyses on bone variables were adjusted for age, BMI, physical activity, calcium intake, years of smoking, current use of thyroid medication and/or statins, and history of bilateral oophorectomy. Bonferroni adjustments were applied in post hoc analyses where appropriate. T-tests were used to assess whether changes within groups were statistically different from zero and to assess differences between AP and lateral T-scores within HRT groups. Baseline differences between groups were assessed by ANCOVA. All analyses of variance utilized type III sum of squares to control for unequal sample size. Bone data were normally distributed and all results were considered statistically significant at an alpha level of $p \leq .05$.

RESULTS

Forty-eight percent of the women in our final sample had never used any form of hormone replacement therapy (HRT) (n=42); 25% had been on HRT since the time of menopause (n=22), 16% initiated HRT at least 10 years after menopause (n=14), and 10% had initiated HRT within the previous 5 years (n=9) (Table 1). Women in the Continual group were on estrogen for an average of 30 years, while the duration of estrogen use among the Late and New groups averaged 12 years and 4 years respectively.

Within the Continual group, 32% of women reported a history of smoking and the average duration they smoked was 7.5 years. Smoking history was considerably lower in the other groups with 10% of the NoHRT and New groups, and 7% of the Late group reporting a history of smoking. The average duration of smoking was between 1-2 years in these groups. One woman in each of the Continual, Late, and New groups were current statin users and 5 women in the NoHRT group were on statins. A family history of osteoporosis was reported in 21% of the women in the NoHRT group, 47% of the women in the Continual group, 46% of the Late group, and 22% of the New group. Approximately 55% of the women on HRT since menopause (Continual) reported a bilateral oophorectomy compared with 14% of the NoHRT and Late groups. None of the women in the New group reported a bilateral oophorectomy. There were no differences between groups with respect to age, height, weight, BMI, smoking history, years past menopause, reported physical activity, total calcium, history of bilateral oophorectomy, or number of births (Table 4.1). Nor were there differences in disease incidence or medication use including statins or thyroid medications between groups.

Total Hip BMD

Multivariate adjusted percentage change in BMD at the total hip adjusted for BMI, age, smoking, physical activity, calcium intake, loss of height, bilateral oophorectomy, current thyroid medication and current statin use showed there was a significant HRT group effect (p=.024). Percentage change was significantly different in the NoHRT group compared to the Continual and New groups (p=.019 and p=.018), respectively, though the differences between groups were negated when a Bonferroni adjustment for multiple comparisons was applied (p=.117; p=.110). There were no differences between HRT groups in total hip BMD at baseline (p=.193). At follow-up, there was a significant HRT group effect (p=.05). Pairwise comparisons revealed the NoHRT group had lower total hip BMD than the Continual group (p=.012) However when a Bonferroni adjustment was applied the statistical significance was reduced (p=.07) (Table 4.2).

Table 4.1 Subject Characteristics by HRT Group (Mean (SD))

Variable	NoHRT n=42	ContinualHRT n=22	LateHRT n=14	NewHRT n=9
Age (years)	78.6 (4.5)	79.1 (4.6)	77.9 (3.5)	78.6 (4.2)
Height (cm)	159.1 (5.3)	158.4 (8.2)	161.0 (6.0)	164.8 (4.2)
Weight (kg)	68.3 (13.8)	65.3 (14.9)	71.3 (13.5)	61.7 (8.6)
Body Mass Index (kg/m^2)	27 (5.1)	26 (5.1)	27.6 (5.8)	22.7 (3.0)
Smoking History (years)	2.2 (8.1)	7.5 (13.4)	1.0 (3.7)	2 (6.3)
Years Past Menopause	30.6 (6.7)	31.4 (8.4)	29.4 (5.3)	27 (5.6)
Years on HRT*	0	30.8 (8.7)	12.3 (4.5)	4.2 (1.2)
PASE Score	140.4 (69.3)	113.8 (57.1)	101.3 (61.4)	139.9 (65.1)
Total ca++ (mg)	1482 (630)	1308 (522)	1387 (515)	1180 (584)
Births	2.6 (1.3)	2.4 (1.5)	3.7 (1.6)	2.1 (1.5)

*All groups differ from one another on years of HRT use

Table 4.2 BMD (g/cm^2) of the Proximal Femur across pattern of estrogen use[a,b]

	NoHRT n=42	Continual n=22	Late n=14	New n=9
Total hip				
Baseline	0.778 ± .018	0.839 ± .027	0.825 ± .031	0.757 ± .040
Follow-up	0.763 ± .018	0.849 ± .026	0.827 ± .031	0.774 ± .039

[a] Data are presented as mean ± standard error.
[b] Adjusted for BMI, age, smoking, physical activity, calcium intake, loss of height, bilateral oophorectomy, current thyroid medication and statin use.

Over the 3 year observation period, only the NoHRT group lost total hip BMD (-1.9% ± .72%) (mean ± SE). Using a one-sample t-test, we found the change in total hip BMD was significantly different from zero in the NoHRT group (p=.014) (Figure 4.1).

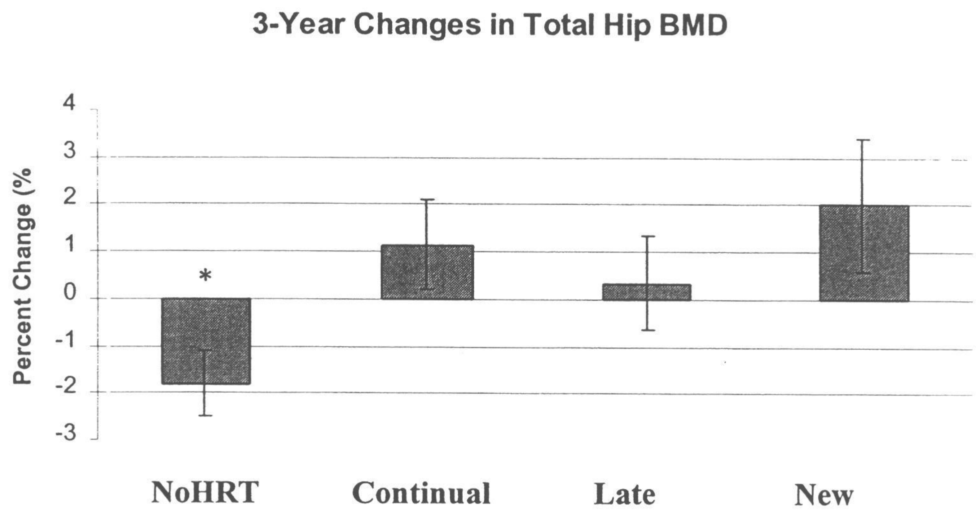

Fig. 4.1 Three-year percentage change in total hip BMD across patterns of estrogen use. Analyses adjusted for BMI, age, smoking, physical activity, calcium intake, loss of height, bilateral oophorectomy, current thyroid medication and statin use. Data are presented as mean ± standard error. The NoHRT lost BMD at the total hip over three years (p=.014).

Lumbar Spine BMD

Obtaining lateral spine data was difficult as many of our participants had curvature of the spine, both medial-laterally (scoliosis) and anterior-posteriorly (swayback). These conditions preclude lateral analysis if the curvature exceeds the limitations of the software. Given these constraints we were able to obtain lateral spine data on a sub-sample of 48 subjects (mean age 78 $\pm$ 4.1 years). Twenty of the 48 women had the iliac crest superimposed over L4 and another 4 women had a severely angled L2 that projected beyond the region of interest for analysis and thus, to maintain our sample size, we analyzed only L3 in the AP and lateral projections. Forty-eight percent of the sub-sample were NoHRT (n=23), 21% were Continual (n=10), 19% were Late (n=9) and 13% were New (n=6). These groups reflected the overall group proportions though the sample sizes were smaller.

There were no differences in multivariate adjusted AP or lateral spine BMD between groups (p=.213 and p=.145, respectively). In order to improve statistical power, we performed a follow-up ANCOVA in which we combined the Continual and Late groups and compared this pooled group to the NoHRT women. Women who had initiated HRT within the last five years were omitted from this analysis. Thus we compared the NoHRT group (n=22) to the pooled group of 19 women who had been on HRT for an extended period of time. Within this combined group the average duration of HRT use was 23.3 $\pm$ 12 years. We found no difference between groups in AP BMD (p=.213). However, the women on HRT had significantly higher lateral BMD compared to women who had never been on HRT (p=.053) (Figure 4.2).

We explored the data further and ran independent t-tests within each group to assess differences between the T-scores of the lateral and AP scans. The T-score represents the standard deviation from adult peak mean BMD and is the current criteria for diagnosing osteoporosis. The NoHRT, Continual, and New groups all had lateral T-scores that were significantly lower than AP T-scores ($p<.001$; $p<.001$; $p=.005$, respectively) (Table 4.3). Both the New and NoHRT groups were classified as osteoporotic on the basis of their lateral scans but were considered normal and osteopenic based on their AP T-scores, while the Continual group was osteopenic based on the lateral T-score, but normal according to the AP T-score. There was no difference between the lateral and AP T-scores among women in the Late group ($p=.072$).

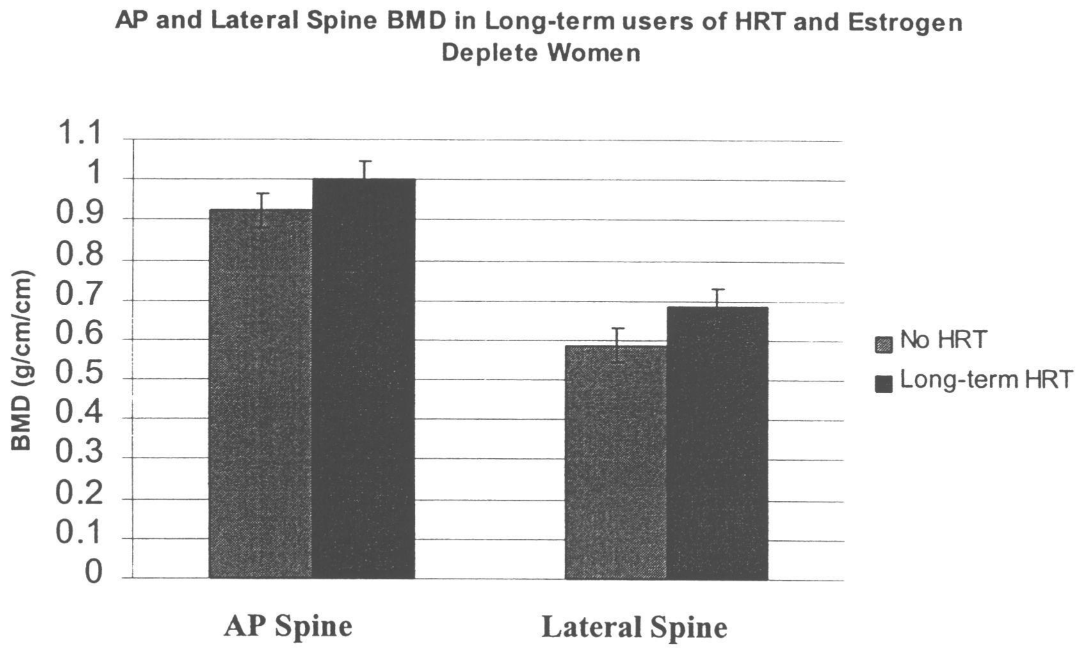

Figure 4.2 Differences in spine BMD measured in the AP and lateral projections. Analyses adjusted for BMI, age, smoking, physical activity, calcium intake, loss of height, bilateral oophorectomy, current thyroid medication and statin use. Long-term HRT users had higher BMD at the lateral spine compared to hormone replete women ($p=.05$). There were no group differences in AP BMD.

Table 4.3 BMD of the lumbar spine (g/cm2) across patterns of estrogen use[a*]

	NoHRT n=22	Continual n=11	Late n=9	New n=6
Lumbar spine				
AP spine[ab]	.911 ± .038	.975 ± .064	1.009 ± .059	1.075 ± .074
Lateral spine[ab]	.586 ± .027	.681 ± .044	.694 ± .041	.598 ± .051
AP T-score[a]	-1.54 ± .29*	-0.63 ± .43*	-0.54 ± .67	-0.72 ± .72*
Lateral T- score[a]	-2.90 ± .23*	-2.30 ± .46*	-1.95 ± .48	-2.85 ± .56*

[a] Data are presented as mean ± standard error. [b] Adjusted for BMI, age, smoking, physical activity, calcium intake, loss of height, bilateral oophorectomy, current thyroid medication and statin use. *Within group t-test differences between lateral and AP T-scores (p<.006).

DISCUSSION

Our first research question asked whether the rate of change in BMD at the total hip differed across patterns of estrogen use in women over 70 years of age. We report only the NoHRT group experienced a loss of BMD at the total hip and this change was significantly different from zero.

Our second research question addressed differences in BMD of the spine as measured in the anterior-posterior and lateral projections across patterns of estrogen use in women over 70 years of age. We found no differences across groups at the lumbar spine measured in the AP or lateral projection. In a follow-up ANCOVA in which we combined the Continual and Late groups and compared them to the NoHRT women, we found that the long-term HRT group had higher BMD at the lateral spine compared to women who had never been on HRT. This effect was not seen at the AP spine.

The primary limitation to our study is the small sample size, particularly within the Late and New groups. Without the stringency of a randomized design, individuals have the freedom to make their own choices about HRT strategies, and in the case of our sample population, far fewer women chose to use HRT, and a very small group initiated within the last 5 years. This may explain why within-group changes failed to reach statistical significance, particularly among those women who chose to initiate HRT within the last 5 years. For example, the New group, whose increase in BMD (2% ± 1.5%) exceeded the loss in BMD of the NoHRT group, was comprised of only 10 women and the standard error was twice that of the NoHRT group. Thus, it is possible the small sample size resulted in the large standard error and contributed to our inability to detect significant group differences. Nevertheless, these data are novel in that very few researchers have examined the bone response to varying the timing of estrogen therapy in such an aged group, and to our knowledge, there have been no studies examining the timing of HRT on BMD of the lateral spine. A second limitation is the observational design. Observational studies cannot provide conclusive evidence to the question of interest and only a randomized controlled trial would be able to establish true differences in the rate of BMD loss among women with varying hormone profiles. However, such a study would be extremely costly and take decades to complete and longitudinal, observational studies provide valuable information in the interim.

Finally, the use of different densitometers at baseline and follow-up to examine hip BMD increased the likelihood of precision error. Though our intraclass correlations were very high between the two machines, the level of agreement between the two methods was not quite as strong.

Though much remains to be learned about the consequences of long-term HRT, its anti-resorptive effect on the skeleton is well known (18). In the present study, women who were not on HRT continued to lose bone at the hip while women on HRT increased BMD or showed no change. This is consistent with the literature showing that even frail older women respond favorably to treatment and that bone loss among untreated older women continues even after 75 years of age (19-21). Despite very few statistically significant findings in our study, there are identifiable patterns related to estrogen use in our sample. The women on HRT continually since menopause had BMD values that averaged 10% higher than the NoHRT group at follow-up, and the Late group had BMD values nearly 8% above those of the NoHRT group. Most interesting was that the New users, whose total hip BMD averaged 2.7% *lower* than the NoHRT group at baseline, were 1.4% *higher* than the NoHRT group at follow-up. Thus it appears that later initiation of HRT has a beneficial effect on the skeleton and because it reduces the duration of estrogen use, later initiation may offset health-related consequences of long-term use.

The difference in BMD at the lateral spine is interesting and requires a great deal more study. Most notable in this study was the lack of a significant difference between women on HRT and estrogen deplete women at the AP spine in contrast to the difference seen between these groups at the lateral spine. Whether these data compare to the findings of others is uncertain as, to our knowledge, nobody has examined differences in lateral BMD by estrogen status. However, there are data indicating that women who have been on HRT since menopause or since 10 years post menopause with long-term continuation, had significantly higher BMD at the hip and AP spine compared to past HRT users and women who had never been on HRT (6). While our findings at the lateral spine support the positive effect of long-term HRT at this skeletal site, we found no beneficial effect of estrogen at the anterior-posterior spine in our sample population. While there are no studies examining BMD at the AP and lateral spine by estrogen use, there are studies that indicate that AP spine measures may have little value in older populations (10, 12). Cross sectional studies have demonstrated that BMD at the AP spine decreases with advancing age (26, 27). However, longitudinal studies have shown that bone loss at the spine, measured in the AP projection ceases in women over 65 (28), or even increases (10). In a longitudinal study of women > 10 years past menopause who were not on HRT, researchers reported an increase in BMD at the AP site (10). These authors suggested that AP spine mass measurements may be of little use in monitoring bone loss in women well past menopause (10). While there are no reports of differences in BMD of the spine in the AP and lateral projections with respect to the timing of HRT, there are data comparing the T-score values at these two sites.

We found that for all but the Late group, the lateral T-score was significantly lower than the AP T-score. In fact, the NoHRT and the New groups would be classified as osteoporotic by the lateral T-score, but were classified as osteopenic and normal, respectively, by the AP T-score. In the Continual group, the AP score was –0.63 (normal) and the lateral score was –2.3 (osteopenia). The difference between the AP and lateral T-scores in this study is representative of other studies in this age group (12, 13, 15, 17). These findings highlight the importance of isolating the vertebral body independent of the posterior elements and age-related artifacts. Perhaps these women would have made different choices about when to initiate HRT given this information earlier. Information regarding not only the T-score but the bone response at the lateral spine may be important in assessing the effectiveness of treatment. Recently, the Study of Osteoporotic Fractures group, found that reductions in vertebral fracture risk were considerably greater than those predicted by the noted improvement in BMD (22). However, these conclusions were based only on BMD of the AP spine. Since vertebral fractures occur in the anterior bodies, isolating this area in the lateral projection would likely produce quite different results that would be in better agreement with reductions in fracture. Results from our study support this hypothesis.

In a 6-year randomized controlled study on the effects of HRT on bone mass in early postmenopausal women, researchers found an especially large effect of HRT on the BMD of the 3^{rd} lumbar vertebrae when assessed laterally (23). In fact, the increase in BMD at this site was about 4% higher than observed at the AP site. It is unclear whether this may hold true for older women as well, but certainly lends support to a shift from AP to lateral spine scanning for diagnosing and treating spinal osteoporosis.

Our results in this sample of older women suggest that long-term HRT is beneficial to the both the hip and lateral spine, and that these benefits may be achieved as late as 10 years past menopause. In addition, the discordant findings at the AP and lateral spine, particularly in the classification of osteoporosis, suggest a need to move toward lateral spine scanning for diagnosing spinal osteoporosis in older women.

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CHAPTER 5

CONCLUSIONS

The etiology of falls leading to hip fractures in older adults is complex and multifactorial. While the factors that cause hip fractures are not completely understood, we do know that falls in the elderly are precipitated by advanced age, female gender, a previous fall, impaired ability to carry out the activities of daily living, presence of disease or disability, decreases in balance and coordination, slow reaction time, reduced lower extremity strength, abnormal gait, and visual impairment (Chu et al., 1999; Ivers et al., 1998; Lee & Kerrigan, 1999; Norton et al., 1997; Schwendner et al., 1997; Studenski et al., 1991). We also know that falls to the side landing on or near one hip pose the greatest risk of a hip fracture (Greenspan et al., 1998; Hayes et al., 1996; Parkkari et al., 1999; Slemenda, 1997; Wei et al., 2001). Thus, it is probable that falls to the side predominate in the 1-2% of all falls that result in hip fracture. Identifying the underlying contributors to side fall risk is paramount to refining prediction models so that we can identify those individuals most at risk for the type of fall likely to result in a hip fracture.

The aim of our first study was to examine 2-year changes in previously identified risk factors for side falls in a population of independent community-dwelling women over 70 years, and to examine whether side-fallers differed from non-fallers and other direction fallers on these risk factors. Our results showed that there was no difference between fall groups on the rate of change in these variables over two years. However, all groups exhibited a decrease in hip abduction strength and tandem walk performance, though these changes were not independent of age. Thus, declines in these variables are not associated with fall status. Though the rate of change was similar between groups, initial values were not. Side fallers exhibited lower hip abduction strength compared to non-fallers both at baseline and follow-up and this effect was observed independent of age. Side-fallers were also slower on the Get Up and Go task, however this difference was only observed at baseline. Interestingly, the only variables associated with physical activity scores in our sample population, were the Get Up and Go task and hip abduction strength.

From the first study, we conclude that, of the variables we have previously shown that predict side-fallers (White et al., 2001), hip abduction strength may be the most sensitive and useful predictor of side fall risk for apparently healthy, independent women over 70 years. It will be important to determine if more frail elderly exhibit similar patterns. Furthermore, given the association of hip abduction strength to physical activity, it is a modifiable risk factor with a properly designed intervention.

Physical contributors to side-fall risk have been studied extensively (Chu et al., 1999; Gunter et al., 2000; Ivers et al., 1998; Judge et al., 1996; Lee & Kerrigan, 1999; Lord & Clark, 1996; Lord et al., 1991; Lord et al., 1999; Norton et al., 1997; Resnick, 1999; Schwendner et al., 1997; Studenski, et al., 1991; Whipple et al., 1987; White et al., 2001; Wolfson et al., 1995). Recently, scientists have begun to recognize the interconnectedness of psychological factors to physical function and subsequently fall risk. Research indicates that fallers exhibit increased fear of falling, lower falls efficacy and decreased balance self-efficacy compared to non-fallers (Arfken et al.,1994; Gunter et al., in press; Maki et al., 1991; Tinetti et al.,1994, 1995). However, whether side-fallers differed from non-fallers or other-direction fallers had not been examined.

The aim of our second study was to examine changes in balance-self efficacy (BSE) over two years and to determine whether side-fallers differed from non-fallers and other-direction fallers in BSE and in the rate of change in BSE. Our results showed there was no difference in the rate of change between groups with respect to BSE scores. However, non-fallers exhibited a slight, but statistically meaningful –2.5% decrease over two years. More research will be necessary to determine whether this is a practically meaningful change. Of obvious practical as well as statistical significance were our findings regarding BSE as a predictor of side-fall risk. We sought to determine whether BSE at baseline could predict performance on side-fall risk variables at follow-up. We found that BSE explained 28% and 14% of the variance in Get Up and Go, and hip abduction strength, respectively. Thus we have learned that although BSE did not differ in side-fallers compared to non-fallers and other-direction fallers, BSE was associated with risk factors for side falls among independent, community-dwelling and as such, should be considered when evaluating side-fall risk. Furthermore, the

Balance Self-Efficacy Scale may have utility in a clinical setting as a screening tool to identify individuals at risk for injurious falls.

The final study in this dissertation was a 3-year prospective examination of bone mineral density (BMD) in a population of independent, elderly, women over 70 years, to determine whether choices regarding hormone replacement therapy (HRT) altered the rate of change in bone among this cohort of women long past menopause. HRT is widely prescribed to postmenopausal women for bone loss and few data examine the bone response to the timing of HRT use in older postmenopausal women. Furthermore, the association between timing of HRT and vertebral trabecular BMD is poorly understood. Specifically, we evaluated the effects the timing of estrogen therapy had on BMD and bone loss at the total hip. In addition we examined the effects the timing of estrogen therapy had on BMD of the anterior-posterior and lateral spine at follow-up.

The results of this study showed only women who had never been on HRT lost BMD at the total hip. At the spine, long-term HRT users had higher lateral spine BMD than women who had never been on HRT. However, in the AP projection, BMD was not different between these two groups.

Our results suggest that long-term HRT is beneficial to the both the hip and lateral spine, and that these benefits may be achieved as late as 10 years past menopause within a population of healthy, independent, community-dwelling, older women. We cannot assume this result among frail elderly, and additional longitudinal studies are necessary to determine whether HRT affords the same benefit to a population of women, who are less active, and more disabled than our population sample. The discordant findings at the AP and lateral spine, particularly in the classification of osteoporosis, warrant further investigation. If T-scores at the lateral spine reflect osteoporotic conditions to the extent that T-scores at the AP spine do, the incidence of osteoporosis is likely considerably higher than statistics reflect.

In summary, we have identified hip abduction strength as perhaps the most sensitive measure of side-fall risk among independent elderly women. Furthermore, we have discovered that balance self-efficacy, a psychological measure of confidence in one's balance specific to the activities of daily living among independent, older women, was predictive of future performance on previously identified risk factors for side falls. And finally, we have found that women who have never been on HRT experienced bone loss at the hip, while long-term users of HRT did not lose bone and exhibited higher BMD at the lateral spine compared to women who had never been on HRT. Thus, the results of this dissertation suggest that interventions to reduce side fall risk, and subsequent hip fractures, should focus on increasing hip abduction strength, and include strategies to increase balance self-efficacy such as including common, but difficult, mobility tasks in an exercise setting. And though we observed BMD changes in our hormone deplete women, improving skeletal health is secondary to reducing hip fracture risk in this population as hip abduction strength decreased to a much greater extent and is more easily modified. However, exercises to increase hip abduction strength would likely have a positive affect on the skeleton as well.

Long-term follow-up of these women will allow us to determine whether additional balance and mobility-related risk factors for side and frequent falls discriminate side-fallers with advancing age, particularly as subjects become increasingly frail, or, whether hip abduction strength remains the most significant indicator of side-fall risk. Long-term follow-up will also allow us to confirm our hypotheses regarding changes in BSE as they relate to transitioning functional status. And finally, we can longitudinally examine changes in the AP spine relative to changes in the lateral spine in order to determine whether there are differences in the rate of change at these two skeletal sites.

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APPENDICES

APPENDIX A

PUBLICATIONS

REFEREED PAPERS (PUBLISHED OR IN PRESS)

Gunter, KB, De Costa, JL, White, KN, Hooker, K, Hayes, WC and Snow, CM. Balance Self-Efficacy predicts risk factors for side falls and frequent falls. *Journal of Aging and Physical Activity*. In press.

White KN, **Gunter KB**, Hayes, WC, Snow, CM. The Quick Step: A New Test for Measuring Reaction Time and Lateral Stepping Velocity. *Journal of Applied Biomechanics*. In press.

Gunter KB, White, KM, Hayes WC, Snow CM. (2000). Functional mobility discriminates non-fallers from one-time and frequent fallers. *Journal of Gerontology:Medical Sciences*, 55:M672-676.

Brilla, LR and **Gunter, KB**. (1995). Effect of magnesium supplementation on exercise time to exhaustion. *Medicine, Exercise, Nutrition and Health*, 4:230-233.

PUBLICATIONS-IN REVIEW

Gunter, K.B., Hayes, W.C., and Snow, C.M. Low hip abduction strength dominates side-fall risk in elderly women. *Medicine and Science in Sports and Exercise*. In review.

Gunter, K.B. and Snow, C.M. Bone response to timing and duration of hormone replacement therapy in women over 70 years. *Menopause*. In review.

Gunter, K.B., Hayes W.C., and Snow, C.M. Balance self-efficacy predicts performance on mobility and balance-related risk factors for side and frequent falls among community-dwelling women over 70 years. *Journal of Gerontology: Psychological Sciences*. In review.

PUBLISHED ABSTRACTS
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Gunter, KB, Hayes, WC, Snow, CM. Relationships Among Side Fall Risk Variables Change With Age. Results from a 2-Year Study in Community Dwelling Women Over 70. 2002, *Med Sci Sports Exerc.,* 34(5):S268.

Gunter, KB, Snow, CM, Shaw, JM. Differences in the ratio of trochanteric to femoral neck BMD in women across the lifespan. 2001, J Bone Minera Res, 16(S1):S320.

Gunter, **KB,** White, KN, De Costa, JL, Hooker, K, Hayes, WC, and Snow, CM. Risk factors for injurious falls predict balance confidence. 2001, *Med Sci Sports Exerc.*, 33(5):S

Hooker, K, De Costa JL, **Gunter, KB**, Hayes, WC, and Snow, CM. Balance Confidence: A unique predictor of health. 2001

De Costa JL, **Gunter, KB**, Hooker, K, Hayes, WC, and Snow, CM. Balance Confidence predicts mental and physical health. 2001

Gunter, KB, White, KN, Hayes, WC and Snow, CM. Frequent and one-time fallers are different from non-fallers on tests of functional ability. 2000, *Med Sci Sports Exerc,* 32(5):S277.

White KN, **Gunter KB**, Hayes WC, Snow CM. Lateral sway is a key predictor of mobility task performance among elderly adults. 2000, *Med Sci Sports Exerc.*, 32(5):S350.

Gunter, KB and Knutzen, KM. Changes in ground reaction forces following heavy resistance training: A study of elderly gait., 1997, *Med Sci Sports Exerc.*, 29(5):S253.

Knutzen, KM. and **Gunter, KB**. Effects of heavy resistance training on stair climbing power in older adults. 1997, *Med Sci Sports Exerc.*, 29(5): S159.

Brilla, LR and **Gunter, KB** (1994). Magnesium Ameliorates Aerobic Contribution at High Intensity Exercise. 1994, *Med Sci Sports Exerc.*,26(5):S53.

APPENDIX B

Informed Consent

Title: The Side Fall Risk Index as a Predictor of Hip Fracture Risk

Investigators: Christine Snow, Ph.D., Associate Professor, 737-6788
Katherine Gunter, Ph.D. Student, 737-5935

Purpose: Of the 350,000 hip fractures annually, over 90% are the result of direct impact to the hip due to a fall to the side. We have identified variables known to be associated with an increased risk of sideways falls. These include medial lateral (side to side) balance, strength, and mobility. Poor performances on these tasks in association with reductions in bone mineral density which are a normal consequence of aging, increase one's risk of experiencing a hip fracture. The purpose of this year-long study is to compare the changes in medial lateral strength, balance and mobility, as well as changes in bone density among individuals over 70 to determine whether side fallers differ from other direction fallers or non-fallers on these variables.

I have been invited to participate in this study because I am currently a participant in the falls surveillance study at the Bone Research Laboratory. Each of the two testing sessions will take approximately 45 minutes to an hour. I will undergo the following procedures twice, at time 0 and 12 months.

Procedures:

1. **Bone Mineral Density Assessment.** Bone mass of my spine and left hip will be measured using an x-ray. This technique gives an accurate measure of bone density with a very low exposure to radiation.

2. **Leg Strength Assessment:** The strength of my right and left hips will be measured with a simple device that I will press the side of my leg against.

3. **Balance**: I will be asked to stand on a stationary platform, with one foot in front of the other, while computer sensors under the platform measure how much I sway.

4. **Reaction and Movement Time:** I will stand in a relaxed position in front of a light signal. When the light turns red I will step to the side as quickly as possible. The test will be repeated 5 times on each leg. I will perform a second test where I will begin standing in a relaxed position and step across my body onto a target placed on the floor in response to the light turning red. This test will also be repeated 5 times for each leg.

5. **Mobility**: I will be asked to walk heel to toe as quickly as possible and to stand up walk a short distance then return to my seat as quickly as possible.

6. **Questionnaires**: I will be asked to fill out balance self-efficacy, physical activity and nutrition questionnaires which ask for details about my confidence during specific activities as well as my exercise and dietary habits.

Risks and Benefits: Measurement of bone mineral density will provide an accurate assessment of my bone mass. Evaluation is diagnostic and questions regarding my bone mineral density report should be directed to my physician. It has been explained to me that an additional benefit of participating in this study is to help identify simple procedures to predict men and women who may be at risk for a side fall.

I understand that the risks involved in performing these tests are minimal. To further reduce any fall risk, I will be assisted by a trained "spotter" at all times. Also, I may experience some minor muscle soreness. This should clear up completely in a day or two. X-ray exposure from bone scans is extremely low. The amount of radiation that I will receive is less than the amount of radiation an average individual receives in one day from background sources (sun, etc).

Confidentiality

I understand that my confidentiality will be maintained and that only the researchers will have access to my results. I have been informed that the results of this study may be published in scientific literature, and that these data will not reveal my name.

Participation and Questions

I understand that participation is voluntary and that I may stop doing a test if it is uncomfortable or may withdraw at any time without penalty. I may contact the researchers Dr. Christine Snow at 541-737-6788, 106 Women's Building, Oregon State University or Kathy Gunter at 541-737-5935, 13 Women's Building, Oregon State University if I have any questions or concerns regarding the study. Any questions that I may have regarding my rights as a research subject should be directed to the IRB Coordinator, OSU Research Office, 541-737-3437.

I have read the above consent form and I agree to participate.

Subject Signature______________________ Date__________________

Investigator's Signature__________________ Date__________________

APPENDIX C

OREGON STATE UNIVERSITY BONE RESEARCH LABORATORY
Health History Questionnaire

Last Name ________ First Name ________ Middle Int. ________ Date of Birth ________

Street Address ________ City, State, Zip ________

Phone Number ________ Email Address ________ Occupation ________

Which describes your racial/ethnic identity? (Please check all that apply)

White, European American, Non Hispanic _____
North African or North African American _____
Black, African American, Non Hispanic _____
Middle Eastern or Middle Eastern American _____
Other: _____
Asian, Asian American _____
Pacific Islander _____
Hispanic or Latino American _____
American Indian or Alaskan Native _____
Decline to Respond _____

Please list your present medications (include vitamins and minerals):

____
____
____
____
____
____
____
____

PAST HISTORY Have you ever had? (Check if yes)

High blood pressure _____
Heart trouble _____
Disease of the arteries _____
Lung disease _____
Orthopedic operations _____
Back injury _____
Cancer _____
Stroke _____
Broken bones _____

PRESENT SYMPTOMS Have you had in the past 6 months? (Check if yes)

Chest pain _____
Shortness of breath _____
Heart palpations _____
Cough on exertion _____
Coughing up blood _____
Painful, stiff or swollen joints _____
Dizziness _____
Fainting _____
Poor balance _____
Poor vision _____
Back pain _____

If you answered "yes" to any of the above, please elaborate:

____
____

____

____

____

____

____

HEALTH HABITS

Alcohol Consumption

Do you drink alcohol? YES NO If "yes", How many drinks/week? ______

Smoking

Do you now smoke? YES NO If "yes", what do you smoke? ______

How many per day? _____ For how many years? _____

If you have quit, when did you quit? ____

How many years did you smoke? ____

APPENDIX D

BALANCE SELF-EFFICACY QUESTIONNAIRE

Balance Self-Efficacy Scale – Version II

Listed below are a series of tasks which you may encounter in daily life. Please indicate how confident you are **today** that you can complete each of these tasks without losing your balance. Your answers are confidential. Please answer as you feel, not as you think you should feel. **Circle the NUMBER that corresponds to your level of confidence, NOT, the wording below the numbers.**

1. How confident are you that you can get up out of a chair **(using your hands)** without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

2. How confident are you that you can get up out of a chair **(not using your hands)** without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

3. How confident are you that you can walk up stairs **(using the handrail)** without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

4. How confident are you that you can walk up the stairs **(<u>not</u> using the handrail)** without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

5. How confident are you that you can get out of bed without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

6. How confident are you that you can get into or out of a shower or bathtub **(<u>with</u> the assistance of a handrail or support wall)** without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

7. How confident are you that you can get into or out of a shower or bathtub (**with no assistance from a handrail or support wall**) without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

8. How confident are you that you can walk down a flight of ten stairs (**using the handrail**) without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

9. How confident are you that you can walk down a flight of ten stairs (**not using the handrail**) without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

10. How confident are you that you can remove an object from a cupboard located at a height that is level with your shoulder without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

11. How confident are you that you can remove an object from a cupboard located at a height that is above your head without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

12. How confident are you that you can walk across uneven ground (**with assistance**) when there is good lighting available without losing your balance balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

13. How confident are you that you can walk across uneven ground (**with no assistance**) when there is good lighting available without losing your balance balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

14. How confident are you that you can walk across uneven ground (**with assistance**) at night without losing your balance balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

15. How confident are you that you can walk across uneven ground **(with no assistance)** at night without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

16. How confident are you that you can stand on one leg **(with support)** while putting on a pair of trousers without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

17. How confident are you that you can stand on one leg **(with no support)** while putting on a pair of trousers without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

18. How confident are you that you can complete a daily task **quickly** without losing your balance?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					somewhat confident				absolutely confident	

Finally, we are interested in understanding what factors affect your confidence levels. Please provide reasons why you answered the way you did on questions 1 through 18 on the lines below. For example, if you were not very confident, why do you feel that way? If you were not very confident about an activity because you no longer do it very often (e.g. climb stairs) we would like to know that also.

____

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APPENDIX E

PHYSICAL ACTIVITY QUESTIONNAIRE

PHYSICAL ACTIVITY SCALE FOR THE ELDERLY

(PASE)

NEW ENGLAND
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RESEARCH
INSTITUTES

LEISURE TIME ACTIVITY

1. Over the past 7 days, how often did you participate in sitting activities such as reading, watching TV or doing handcrafts?

[0.] NEVER → GO TO Q.#2 [1.] SELDOM (1-2 DAYS) [2.] SOMETIMES (3-4 DAYS) [3.] OFTEN (5-7 DAYS)

1a. What were these activities?

____

1b. On average, how many hours per day did you engage in these sitting activities?

[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS

[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

2. Over the past 7 days, how often did you take a walk outside your home or yard for any reason? For example, for fun or exercise, walking to work, walking the dog, etc.?

[0.] NEVER → GO TO Q.#3 [1.] SELDOM (1-2 DAYS) [2.] SOMETIMES (3-4 DAYS) [3.] OFTEN (5-7 DAYS)

2a. On average, how many hours per day did you spend walking?

[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS

[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

3. Over the past 7 days, how often did you engage in light sport or recreational activities such as bowling, golf with a cart, shuffleboard, fishing from a boat or pier or other similar activities?

[0.] NEVER → GO TO Q.#4 | [1.] SELDOM (1-2 DAYS) | [2.] SOMETIMES (3-4 DAYS) | [3.] OFTEN (5-7 DAYS)

3a. What were these activities?

____

3b. On average, how many hours per day did you engage in these light sport or recreational activities?

[1.] LESS THAN 1 HOUR
[2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS
[4.] MORE THAN 4 HOURS

4. Over the past 7 days, how often did you engage in moderate sport and recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball or other similar activities?

[0.] NEVER → GO TO Q.#5 | [1.] SELDOM (1-2 DAYS) | [2.] SOMETIMES (3-4 DAYS) | [3.] OFTEN (5-7 DAYS)

4a. What were these activities?

____

4b. On average, how many hours per day did you engage in these moderate sport and recreational activities?

[1.] LESS THAN 1 HOUR
[2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS
[4.] MORE THAN 4 HOURS

5. Over the past 7 days, how often did you engage in strenuous sport and recreational activities such as jogging, swimming. cycling, singles tennis, aerobic dance, skiing (downhill or cross-country) or other similar activities?

[0.] NEVER ↓ GO TO Q.#6

[1.] SELDOM (1-2 DAYS) ↓

[2.] SOMETIMES (3-4 DAYS) ↓

[3.] OFTEN (5-7 DAYS) ↓

5a. What were these activities?

____

5b. On average, how many hours per day did you engage in these strenuous sport and recreational activities?

[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS

[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

6. Over the past 7 days, how often did you do any exercises specifically to increase muscle strength and endurance, such as lifting weights or pushups, etc.?

[0.] NEVER ↓ GO TO Q.#7

[1.] SELDOM (1-2 DAYS) ↓

[2.] SOMETIMES (3-4 DAYS) ↓

[3.] OFTEN (5-7 DAYS) ↓

6a. What were these activities?

____

6b. On average, how many hours per day did you engage in exercises to increase muscle strength and endurance?

[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS

[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

HOUSEHOLD ACTIVITY

7. During the past 7 days, have you done any light housework, such as dusting or washing dishes?

   [1.] NO [2.] YES

8. During the past 7 days, have you done any heavy housework or chores, such as vacuuming, scrubbing floors, washing windows, or carrying wood?

   [1.] NO [2.] YES

9. During the past 7 days, did you engage in any of the following activities?

   Please answer YES or NO for each item.

		NO	YES
a.	Home repairs like painting, wallpapering, electrical work, etc.	1	2
b.	Lawn work or yard care, including snow or leaf removal, wood chopping, etc.	1	2
c.	Outdoor gardening	1	2
d.	Caring for an other person, such as children, dependent spouse, or an other adult	1	2

WORK-RELATED ACTIVITY

10. During the past 7 days, did you work for pay or as a volunteer?

[1.] NO [2.] YES

10a. How many hours per week did you work for pay and/or as a volunteer?

_______________ HOURS

10b. Which of the following categories best describes the amount of physical activity required on your job and/or volunteer work?

[1] Mainly sitting with slight arm movements. [Examples: office worker, watchmaker, seated assembly line worker, bus driver, etc.]

[2] Sitting or standing with some walking. [Examples: cashier, general office worker, light tool and machinery worker.]

[3] Walking, with some handling of materials generally weighing less than 50 pounds. [Examples: mailman, waiter/waitress, construction worker, heavy tool and machinery worker.]

[4] Walking and heavy manual work often requiring handling of materials weighing over 50 pounds. [Examples: lumberjack, stone mason, farm or general laborer.]

APPENDIX F

NUTRITION QUESTIONNAIRE

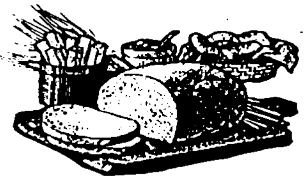
BRIEF FOOD QUESTIONNAIRE

RESPONDENT ID NUMBER

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

TODAY'S DATE

	DAY		YEAR
O Jan			
O Feb			
O Mar	0	0	2000 O
O Apr	1	1	2001 O
O May	2	2	2002 O
O Jun	3	3	2003 O
O Jul		4	2004 O
O Aug		5	2005 O
O Sep		6	2006 O
O Oct		7	2007 O
O Nov		8	2008 O
O Dec		9	2009 O



This form is about the foods you usually eat.
It will take about 15 - 25 minutes to complete.

- Please answer each question as best you can. Estimate if you aren't sure.
- Use only a No. 2 pencil.
- Fill in the circles completely, and erase completely if you make any changes.

Please print your name in this box.

SEX
O Male
O Female

If female, are you pregnant or breast feeding?
O No
O Yes
O Not female

AGE		WEIGHT pounds			HEIGHT ft.	in.
0	0	0	0	0		0
1	1	1	1	1		1
2	2	2	2	2		2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5		5	5	5	5
6	6		6	6	6	6
7	7		7	7		7
8	8		8	8		8
9	9		9	9		9
						10
						11

This form is about your usual eating habits in the past year or so. This includes all meals or snacks, at home or in a restaurant or carry-out. There are two kinds of questions for each food.

HOW OFTEN, on average, did you eat the food during the past year?
*Please DO NOT SKIP any foods. Mark "Never" if you didn't eat it.

HOW MUCH did you usually eat of the food?
*Sometimes we ask how <u>many</u> you eat, such as 1 egg, 2 eggs, etc., ON THE DAYS YOU EAT IT.
*Sometimes we ask "how much" as A, B, C or D. LOOK AT THE ENCLOSED PICTURES. For each food, pick the picture (bowls or plates) that looks the most like the serving size you usually eat. (If you don't have pictures: A=1/4 cup, B=1/2 cup, C=1 cup, D= 2 cups.)

EXAMPLE: This person drank apple juice twice a week, and had one glass each time. Once a week he ate a "C"-sized serving of rice (about 1 cup).

TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR									HOW MUCH EACH TIME SEE PORTION SIZE PICTURES FOR A-B-C-D				
	NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY					
Apple juice	O	O	O	O	O	●	O	O	O	How many glasses each time	● 1	O 2	O 3	O 4
Rice	O	O	O	O	●	O	O	O	O	How much each time	O A	O B	● C	O D

PLEASE DO NOT WRITE IN THIS AREA

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TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME SEE PORTION SIZE PICTURES FOR A-B-C-D				
How often do you eat each of the following foods all year round?														
Eggs, including egg biscuits or Egg McMuffins (Not egg substitutes)	O	O	O	O	O	O	O	O	O	How many eggs each time	O 1	O 2	O 3	O 4
Bacon or breakfast sausage, including sausage biscuit	O	O	O	O	O	O	O	O	O	How many pieces	O 1	O 2	O 3	O 4
Cooked cereals like oatmeal, cream of wheat or grits	O	O	O	O	O	O	O	O	O	Which bowl		O B	O C	O D
Cold cereals like Corn Flakes, Cheerios, Special K, fiber cereals	O	O	O	O	O	O	O	O	O	Which bowl		O B	O C	O D
Which cereal do you eat most often? MARK ONLY ONE: O Product 19, Just Right, Total; O Bran Buds, Raisin Bran, Fruit-n-Fiber, other fiber cereals; O Other cold cereal, like Corn Flakes, Cheerios, Special K														
Cheese, sliced cheese or cheese spread, including on sandwiches.	O	O	O	O	O	O	O	O	O	How many slices	O 1	O 2	O 3	O 4
Yogurt (not frozen yogurt)	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
How often do you eat each of the following fruits?														
Bananas	O	O	O	O	O	O	O	O	O	How many each time	O 1/2	O 1	O 2	O 3
Apples or pears	O	O	O	O	O	O	O	O	O	How many	O 1/2	O 1	O 2	O 3
Oranges, tangerines, not including juice	O	O	O	O	O	O	O	O	O	How many	O 1/2	O 1	O 2	O 3
Applesauce, fruit cocktail, or any canned fruit	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Any other fruit, like grapes, melon, strawberries, peaches,	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D

TYPE OF FOOD	NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME - SEE PORTION SIZE PICTURES FOR A-B-C-D				
How often do you eat each of the following vegetables, including fresh, frozen, canned or in stir fry, at home or in a restaurant?														
French fries, fried potatoes or hash browns	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
White potatoes not fried, incl. boiled, baked, mashed & potato salad	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Sweet potatoes, yams, or sweet potato pie	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Rice, or dishes made with rice	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Baked beans, chili with beans, pintos, any other dried beans	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Refried beans	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Green beans or green peas	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Broccoli	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Carrots, or stews or mixed vegetables containing carrots	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Spinach, or greens like collards	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Cole slaw, cabbage	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Green salad	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Raw tomatoes, including in salad	O	O	O	O	O	O	O	O	O	How much	O 1/4	O 1/2	O 1	O 2
Catsup, salsa or chile peppers	O	O	O	O	O	O	O	O	O	How many TBSP.	O 1	O 2	O 3	O 4
Salad dressing or mayonnaise (Not lowfat)	O	O	O	O	O	O	O	O	O	How many TBSP.	O 1	O 2	O 3	O 4
Any other vegetable, like corn, squash, okra, cooked green peppers, cooked onions	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Vegetable soup, vegetable beef, chicken vegetable, or tomato soup	O	O	O	O	O	O	O	O	O	Which bowl		O B	O C	O D

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PLEASE DO NOT WRITE IN THIS AREA

TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR									HOW MUCH EACH TIME SEE PORTION SIZE PICTURES FOR A-B-C-D				
	NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY					
MEATS														
Do you ever eat chicken, meat or fish? O Yes O No IF NO, SKIP TO NEXT PAGE														
Hamburgers, cheeseburgers, meat loaf, at home or in a restaurant	O	O	O	O	O	O	O	O	O	How much meat	O 1/8 lb.	O 1/4 lb.	O 1/2 lb.	O 3/4 lb.
Tacos, burritos, enchiladas, tamales	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Beef steaks, roasts, pot roast, or in frozen dinners or sandwiches	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Pork, including chops, roasts, or dinner ham	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
When you eat beef or pork, do you O Avoid eating the fat O Sometimes eat the fat O Often eat the fat O I don't eat meat														
Mixed dishes with meat or chicken, like stew, corned beef hash, chicken & dumplings, or in frozen meals	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Fried chicken, at home or in a restaurant	O	O	O	O	O	O	O	O	O	# medium pieces	O 1	O 2	O 3	O 4
Chicken or turkey not fried, such as baked, grilled, or on sandwiches	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
When you eat chicken, do you O Avoid eating the skin O Sometimes eat the skin O Often eat the skin O N/A														
Fried fish or fish sandwich, at home or in a restaurant	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Any other fish or shellfish not fried, including tuna	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Hot dogs, or sausage like Polish, Italian or Chorizo	O	O	O	O	O	O	O	O	O	How many	O 1	O 2	O 3	O 4
Boloney, sliced ham, turkey lunch meat, other lunch meat	O	O	O	O	O	O	O	O	O	How many slices	O 1	O 2	O 3	O 4
When you eat lunch meats, are they O Usually low-fat O Sometimes O Rarely low-fat O N/A														

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TYPE OF FOOD	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME SEE PORTION SIZE PICTURES FOR A-B-C-D				
Pasta, breads, spreads, snacks														
Spaghetti, lasagna, or other pasta with tomato sauce	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Cheese dishes without tomato sauce, like macaroni and cheese	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Pizza, including carry-out	O	O	O	O	O	O	O	O	O	How many slices	O 1	O 2	O 3	O 4
Biscuits, muffins	O	O	O	O	O	O	O	O	O	How many each time	O 1	O 2	O 3	O 4
Rolls, hamburger buns, English muffins, bagels	O	O	O	O	O	O	O	O	O	How many each time	O 1/2	O 1	O 2	O 3
White bread or toast, including French, Italian, or in sandwiches	O	O	O	O	O	O	O	O	O	How many slices	O 1	O 2	O 3	O 4
Dark bread like rye or whole wheat, including in sandwiches	O	O	O	O	O	O	O	O	O	How many slices	O 1	O 2	O 3	O 4
Tortillas	O	O	O	O	O	O	O	O	O	How many each time	O 1	O 2	O 3	O 4
Margarine on bread, potatoes or vegetables	O	O	O	O	O	O	O	O	O	How many pats (Tsp.)	O 1	O 2	O 3	O 4
Butter on bread, potatoes or vegetables	O	O	O	O	O	O	O	O	O	How many pats (Tsp.)	O 1	O 2	O 3	O 4
Peanuts or peanut butter	O	O	O	O	O	O	O	O	O	How many TBSP.	O 1	O 2	O 3	O 4
Snacks like potato chips, corn chips, popcorn (Not pretzels)	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
Doughnuts, cake, pastry, pie	O	O	O	O	O	O	O	O	O	How many pieces	O 1	O 2	O 3	O 4
Cookies (Not lowfat)	O	O	O	O	O	O	O	O	O	How many	O 1-2	O 3-5	O 6-7	O 8+
Ice cream, frozen yogurt, ice cream bars	O	O	O	O	O	O	O	O	O	How much	O A	O B	O C	O D
When you eat ice cream or frozen yogurt, is it	O Usually low-fat		O Sometimes			O Rarely low-fat			O N/A					
Chocolate candy, candy bars	O	O	O	O	O	O	O	O	O	How many bars	O 1 small	O 1 medium	O 1 large	O 2 large

TYPE OF BEVERAGE	HOW OFTEN IN THE PAST YEAR: NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME SEE PORTION SIZE PICTURES FOR A-B-C-D				
How often do you drink the following beverages?														
Real orange or grapefruit juice, Welch's grape juice, Minutemaid juices, Juicy Juice	○	○	○	○	○	○	○	○	○	How many glasses each time	○ 1	○ 2	○ 3	○ 4
Hawaiian Punch, Sunny Delight, Hi-C, Tang, or Ocean Spray juices	○	○	○	○	○	○	○	○	○	How many glasses each time	○ 1	○ 2	○ 3	○ 4
Kool Aid, Capri Sun or Knudsen juices	○	○	○	○	○	○	○	○	○	How many glasses each time	○ 1	○ 2	○ 3	○ 4
Instant breakfast milkshakes like Carnation, diet shakes like Slimfast, or liquid supplements like Ensure	○	○	○	○	○	○	○	○	○	How many glasses or cans	○ 1	○ 2	○ 3	○ 4
Glasses of milk (any kind)	○	○	○	○	○	○	○	○	○	How many glasses	○ 1	○ 2	○ 3	○ 4

When you drink glasses of milk what kind do you usually drink? **MARK ONLY ONE:**

○ Whole milk
○ Reduced fat 2% milk
○ Low-fat 1% milk
○ Non-fat milk
○ Rice milk
○ Soy milk
○ I don't drink milk or soy milk

TYPE OF BEVERAGE	NEVER	A FEW TIMES per YEAR	ONCE per MONTH	2-3 TIMES per MONTH	ONCE per WEEK	TWICE per WEEK	3-4 TIMES per WEEK	5-6 TIMES per WEEK	EVERY DAY	HOW MUCH EACH TIME				
Cream, Half-and-Half or non-dairy creamer in coffee or tea	○	○	○	○	○	○	○	○	○	Total TBSP. on those days	○ 1	○ 2	○ 3-4	○ 5+
Regular soft drinks, or bottled drinks like Snapple (Not diet drinks)	○	○	○	○	○	○	○	○	○	How many bottles or cans	○ 1	○ 2	○ 3-4	○ 5+
Beer	○	○	○	○	○	○	○	○	○	How many bottles or cans	○ 1	○ 2	○ 3-4	○ 5+
Wine or wine coolers	○	○	○	○	○	○	○	○	○	How many glasses	○ 1	○ 2	○ 3-4	○ 5+
Liquor or mixed drinks	○	○	○	○	○	○	○	○	○	How many drinks	○ 1	○ 2	○ 3-4	○ 5+

During the past year, have you taken any vitamins or minerals regularly, at least once a month?

O No, not regularly O Yes, fairly regularly

(IF YES) WHAT DID YOU TAKE FAIRLY REGULARLY?

VITAMIN TYPE	HOW OFTEN					FOR HOW MANY YEARS?					
	DIDN'T TAKE	A FEW DAYS per MONTH	1-3 DAYS per WEEK	4-6 DAYS per WEEK	EVERY DAY	LESS THAN 1 YR.	1 YEAR	2 YEARS	3-4 YEARS	5-9 YEARS	10+ YEARS
Multiple Vitamins. Did you take...											
Regular Once-A-Day, Centrum, or Thera type	O	O	O	O	O	O	O	O	O	O	O
Stress-tabs or B-Complex type	O	O	O	O	O	O	O	O	O	O	O
Antioxidant combination type	O	O	O	O	O	O	O	O	O	O	O
Single Vitamins (not part of multiple vitamins)											
Vitamin A (not beta-carotene)	O	O	O	O	O	O	O	O	O	O	O
Beta-carotene	O	O	O	O	O	O	O	O	O	O	O
Vitamin C	O	O	O	O	O	O	O	O	O	O	O
Vitamin E	O	O	O	O	O	O	O	O	O	O	O
Folic acid, folate	O	O	O	O	O	O	O	O	O	O	O
Calcium or Tums, alone or combined with vit. D or magnesium	O	O	O	O	O	O	O	O	O	O	O
Zinc	O	O	O	O	O	O	O	O	O	O	O
Iron	O	O	O	O	O	O	O	O	O	O	O
Selenium	O	O	O	O	O	O	O	O	O	O	O
Vitamin D, alone or combined with calcium	O	O	O	O	O	O	O	O	O	O	O

If you took vitamin C or vitamin E:

How many milligrams of **vitamin C** did you usually take, on the days you took it?

O 100 O 250 O 500 O 750 O 1000 O 1500 O 2000 O 3000+ O don't know

How many IUs of **vitamin E** did you usually take, on the days you took it?

O 100 O 200 O 300 O 400 O 600 O 800 O 1000 O 2000+ O don't know

How often do you use fat or oil in cooking?

O Less than once per week O A few times per week O Once a day O Twice a day O 3+ per day

What kinds of fat or oil do you usually use in cooking? MARK ONLY ONE OR TWO

O Don't know, or Pam O Butter/margarine blend O Lard, fatback, bacon fat
O Stick margarine O Low-fat margarine O Crisco
O Soft tub margarine O Corn oil, vegetable oil
O Butter O Olive oil or canola oil

Did you ever drink more beer, wine or liquor than you do now? O Yes O No

Do you smoke cigarettes now? O Yes O No

IF YES, On the average about how many cigarettes a day do you smoke now?

O 1-5 O 6-14 O 15-24 O 25-34 O 35 or more

What is your ethnic group? (MARK ONE OR MORE)

O Hispanic or Latino O Black or African American O American Indian or Alaska Native
O White, not Hispanic O Asian O Native Hawaiian or Other Pacific Islander

Thank you very much for filling out this questionnaire. Please take a minute to go back and fill in anything you may have skipped.

PLEASE DO NOT WRITE IN THIS AREA