The Role of Postural Stability and Other Factors in Distal Radius Fracture

Sheena Saju Philip
The University of Western Ontario

Supervisor
Dr. Joy C. MacDermid
The University of Western Ontario

Graduate Program in Health and Rehabilitation Sciences

A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

© Sheena Saju Philip 2016

Follow this and additional works at: http://ir.lib.uwo.ca/etd

Part of the Orthopedics Commons, Physical Therapy Commons, Preventive Medicine Commons, and the Public Health Education and Promotion Commons

Recommended Citation
http://ir.lib.uwo.ca/etd/4037

This Dissertation/Thesis is brought to you for free and open access by Scholarship@Western. It has been accepted for inclusion in Electronic Thesis and Dissertation Repository by an authorized administrator of Scholarship@Western. For more information, please contact tadam@uwo.ca.
Abstract

The objective of the thesis was to describe the factors leading to falls in distal radius fracture (DRF) events, explore patient perceived risk of falls, and postural stability. A mixed method study described the type of fall in DRF patients (n= 1454) and patient perceived contributing factors (n=29). A prospective cohort study examined the postural stability and related fall risk of DRF participants (n=137) in Biodex Balance System (BBS) and compared to normative values. Environmental factors were a major contributor to DRF events. Older adults (44 to 65 years) had the highest rate of DRF (female: male ratio of 2:1). Only a minority (12%) of DRF participants were at fall risk according to BBS fall risk score. There was no significant change in fall risk or postural stability score in the year following a DRF event.

Keywords: Distal radius fracture, risk factors, fall risk, postural stability, Biodex Balance System.
Co-Authorship Statement

Under the guidance of my supervisor Dr. Joy C MacDermid, two research questions were developed. The advisory committee members (Dr. Dave Walton and Dr. Ruby Grewal) reviewed the manuscript and provided feedback. Ms. Saranya Nair collected the qualitative data. I conducted the statistical analysis, interpreted the results and drafted the manuscripts.
Acknowledgments

I would like first to thank my God, who is the author of my life. I extend my deepest gratitude to my supervisor Dr. Joy C. MacDermid for her continued guidance and patience. Her knowledge and insight were an inspiration for my study. I would also like to thank my advisory committee Dr. Dave Walton and Dr. Ruby Grewal for their feedback and support. Many thanks to research assistant Dr. Joshua Vincent and administrative assistants Ms. Lomoton Margaret and Ms. Katrina Munro for the timely response to enquiries. I would also like to acknowledge my colleagues at HULC lab for their constructive criticism. Canadian Institutes of Health Research (CIHR) provided the financial support for the study (Funding Reference Number: 93372). Finally, I am grateful to my family for their endurance and support in the course of my study.
# Table of Contents

Abstract .............................................................................................................................................. i

Co-Authorship Statement .................................................................................................................... ii

Acknowledgments ............................................................................................................................. iii

List of Tables ....................................................................................................................................... vii

List of Figures ...................................................................................................................................... viii

Chapter 1: Introduction ......................................................................................................................... 1
  1.1 Fracture Risk ................................................................................................................................. 2
  1.2 Fall Risk .......................................................................................................................................... 3
  1.3 Role of Physiotherapy in Fall and Fracture Prevention ............................................................... 4
  1.4 The Mechanism and Incidence of DRF ....................................................................................... 5
  1.5 Classification ............................................................................................................................... 6
  1.6 Epidemiology ............................................................................................................................. 6
  1.7 Research Questions ..................................................................................................................... 8
  1.8 References ................................................................................................................................... 9

Chapter 2: What Factors Contribute to Fall Which Leads to Distal Radius Fracture? .............. 19
  2.1 Introduction ................................................................................................................................... 19
    2.1.1 Objective ............................................................................................................................... 20
  2.2 Methods ....................................................................................................................................... 20
    2.2.1 Research Design ................................................................................................................ 20
    2.2.2 Quantitative Data ................................................................................................................ 21
    2.2.3 Qualitative Data ................................................................................................................ 22
2.2.4 Triangulation of Quantitative and Qualitative Data

2.3 Results

2.3.1 Quantitative Analysis

2.3.2 Qualitative Analysis

2.3.3 Triangulation of Quantitative and Qualitative Methods

2.4 Discussion

Chapter 3

Is balance a problem in Patients with Distal Radius Fracture?

3.1 Introduction

3.1.1 Objectives

3.2 Method

3.2.1 Research Design

3.2.2 Ethics

3.2.3 Participants

3.2.4 Procedure

3.2.5 Statistical Analysis

3.3 Results

3.3.1 Demographics

3.3.2 Fall Risk (BBS Fall Risk Index)

3.3.3 Postural Stability

3.3.4 BBS Zones

3.3.5 Change in Postural Stability and Fall Risk Index Over the Year Following a DRF
3.3.5 Comparison Between Patients Aged Below and Above 65 .......................... 51
3.3.6 Comparison Between Gender ...................................................................... 53
3.4 Discussion ........................................................................................................... 55
3.4.1 Limitations ....................................................................................................... 58
3.4.2 Strengths ........................................................................................................... 58
3.4.3 Implications ...................................................................................................... 58
3.4.4 Research Recommendation ............................................................................. 59
3.5 Conclusion ............................................................................................................ 59
3.6 References ........................................................................................................... 60

Chapter 4: Discussion .................................................................................................. 67
4.1 Limitations ............................................................................................................. 70
4.2 Strengths ............................................................................................................... 71
4.4 Directions for Future Research ............................................................................. 72
4.5 Conclusion ............................................................................................................. 72
4.6 References ............................................................................................................. 73

Appendices ..................................................................................................................... 75
Appendix A: Ethics Approval ....................................................................................... 76
Appendix B: Assessment Forms ................................................................................... 76
Appendix C: Biodex Balance System (Fall Risk and Postural stability) Assessment
Protocol .......................................................................................................................... 80
Appendix D: Curriculum Vitae ..................................................................................... 82
List of Tables

Table 1  Demographic Characteristics of Participants ..........................................................23
Table 2  Mechanism of Fracture According to Age Group .......................................................26
Table 3  Energy Level of Fracture (Low, Medium and High) According to Age Group .......27
Table 4  Work Status According to Age Group ........................................................................28
Table 5  Fall Risk Score at Different Time Point Compared to the BBS Normative Data ........................................................................................................................................48
Table 6  BBS Fall Risk Index and Postural Stability Adjusted Mean over Time ..................49
Table 7  BBS Fall Risk Index tests of Within Subject Effects Controlling for Age and Gender ........................................................................................................................................50
Table 8  BBS Postural Stability Tests of Within Subjects Effects Controlling for Age and Gender ........................................................................................................................................51
Table 9  Fall Risk and Postural Stability Mean Score by Age Group .....................................52
Table 10 Test of Fall Risk Between-subjects Effects by Age Group (Above and Below 65) ........................................................................................................................................52
Table 11 Test of Postural Stability Between- Subjects Effects by Age Group (Above and Below 65) ........................................................................................................................................53
Table 12 Fall Risk and Postural Stability Mean by Gender .....................................................54
Table 13  Test of Fall Risk Between- Subjects Effects by Gender ..........................................54
Table 14 Test of Postural Stability Between- Subjects Effects by Gender .............................55
List of Figures

Figure 1 : Concurrent Triangulation Design .................................................................21

Figure 2 : Frequency of Fracture According to Age Group..............................................24

Figure 3 : Frequency of DRF by Gender ........................................................................25

Figure 4 : Overall Energy level of Fracture ....................................................................27

Figure 5 : Frequency of DRF According to Work Status .................................................28

Figure 6 : Frequency of Fracture According to Calendar Months.................................29
Chapter 1: Introduction

Distal radius fracture (DRF) is a common fracture among seniors and young adults (Milutinovic, Andjelkovic, Palibrk, Zagorac, & Bumbasirevic, 2013; Nellans, Kowalski & Chung, 2012). DRF is a fracture of the radius bone at the lower end proximal to the wrist. The more recent increase in the number of active, healthy seniors, general changes in lifestyle and average life span has impacted the rate of DRF (Ring & Jupiter, 2004). An in-depth analysis of various DRF risk factors may help in formulating preventive public health strategies and may reduce the functional and financial burden associated with it.

The predisposing factors of DRF are numerous. The two strongest predictors of DRF are osteoporosis and falls (Gudmundsdottir, R. S., 2014). Osteoporosis coupled with a fall from standing height often results in a fragility fracture. A fragility fracture according to the World Health Organization (WHO), is “a fracture caused by injury that would be insufficient to fracture normal bone”. Clinically, “a fragility fracture may be defined as one that occurs as a result of minimal trauma, such as a fall from a standing height or less, or no identifiable trauma” (Brown, Jacques P., & Robert G. J., 2002). DRF is a predictor of future additional fractures. A three-fold increase in the risk of a future wrist fracture and a two-fold increase in the risk of other fractures are observed in patients who have experienced a prior wrist fracture (Barrett-Connor et al., 2007). Bone-related and fall-related risk factors are shown to be major contributors to the risk of fractures (Van Helden, 2008). Therefore, it is important to develop an informed and effective preventive strategy to minimize the risk of an initial DRF and subsequent future fractures.
1.1 Fracture Risk

In 2002 Brown et al. identified low bone mineral density (BMD), prior fragility fracture, age and family history of osteoporosis to be the major predictors of all fractures. With ageing, there is a general loss of trabecular and cortical bone integrity which leads to osteoporosis and fracture (Francis, 2001). Osteoporosis is a silent disease typically recognised after a fragility fracture occurs. In 2010, the overall cost of treating osteoporosis and related fractures within the Canadian healthcare system was $2.3 billion (Osteoporosis Facts & Statistics, 2016). However, osteoporosis is considered as a disease of the ageing process and primary care physicians typically place a low priority to fracture prevention strategies (Eisman et al., 2012). However, Stone et al. (2003) observed that there is only a modest proportion of fractures, attributed to osteoporosis.

The risk factors for fractures are multifactorial (Downey, Perry, & Anderson, 2013). Loss of height, a history of falls, and low dietary calcium intake are risk factors for fractures specific to upper limb (Nguyen, 2001). There are also impairments and diseases that develop with ageing that have an impact on all fracture incidence. Postural sway (Nakamura et al., 2010), quadriceps weakness (Pham, Nguyen, Center, Eisman, & Nguyen, 2015), diseases such as Alzheimer’s diseases (Liang & Wang, 2016), diabetes (Schwartz et al., 2001), rheumatoid arthritis (Cooper, Coupland, & Mitchell, 1995), are some of the factors shown to be associated with enhanced fracture risk. Extrinsic factors such as lifestyle of the older population play a crucial role in fracture risk. Some of the lifestyle factors associated with increased risk of fracture are alcohol consumption (Kanis et al., 2004), smoking and low physical activity (Khatib et al., 2014).
1.2 Fall Risk

Fall risk is a strong independent determinant of fracture in the older population. Falls account for 87% of fractures reported in the elderly (Ambrose, Cruz, & Paul, 2015). In 2009/2010 alone more than 256,000 adults above the age of 65 had reported a fall-related injury (Public Health Agency of Canada, 2014). The risk factors for fall are complex and numerous. Based on the characteristic of a fall, risk factors can be broadly classified into biological, behavioural, environmental and socioeconomic categories (World Health Organization, 2007). Biological factors refer to intrinsic characteristics of an individual that are related to body structure and function. Behavioural factors reflect human actions based on individual’s choice and emotions. Environmental risk factors are extrinsic factors present in the surroundings such as cluttered floors and uneven pavements. Socioeconomic factors are related to the social and economic status of an individual (World Health Organization, 2007). The biological risk factors of falls are: chronic disease conditions (Sibley, Voth, Munce, Straus, & Jaglal, 2014), gait patterns (Pavol, Owings, Foley, & Grabiner, 1999; Deandrea et al., 2010), weak muscles (Moreland, Richardson, Goldsmith, & Clase, 2004), balance impairment (Oliveira et al., 2015), poor vision (Lord, 2006) and cognitive impairments (Muir, Gopaul, & Montero Odasso, 2012). Behavioural factors such as fear of falling (Scheffer, Schuermans, van Dijk, van der Hooft, & de Rooij, 2007); type of footwear worn (Sherrington, 2003) lack of attention, pace of movement, lack of confidence and over exertion are shown to have an association with fall risk (Clemson, L., Manor, D., & Fitzgerald, M. H., 2003). One-third of falls in community-dwelling elders is due to environmental hazards (Tinetti, Speechley, & Ginter, 1988). Unfixed rugs, poor lighting, uneven pavement, snow and cluttered floors
contribute to slip or trip events resulting in falls and subsequent fractures (Berg, Cassells, & Stokes, 1992). Socioeconomic factors such as poor nutrition (Torres et al., 2015), ethnicity (Bloch et al., 2010) and living conditions are also associated with a high risk of falling.

1.3 Role of Physiotherapy in Fall and Fracture Prevention

Physiotherapists possess expertise in assessments, interventions, prevention measures and health education which are each an asset in fall and fracture prevention measures. A physiotherapist is a patient-centered autonomous practitioner with clinical knowledge in enhancing physical activity participation, improving functional independence and ensuring general health and wellness. Being an independent specialist, with expertise in screening, assessment and interventions, physiotherapists have a broad scope of knowledge in detecting older adults at a risk of a fall. Screening should incorporate assessment of lifestyle (activity level, smoking, alcohol consumption and nutrition), history of falls and medical history with emphasis on medications and comorbidities apart from the routine physical assessments (Perry & Downey, 2011). Understanding the context of a fall is important as falls can occur due to multiple factors and are unique to each individual (Sherrington & Tiedemann, 2015). Physiotherapist scope of intervention includes pain management, strength training, balance training, gait training, modification of footwear and addressing environmental hazards (Avin et al., 2015). Individually tailored exercise therapy interventions have multiple benefits. Exercise therapy maintains physical function and bone health. High-impact exercise promotes osteogenesis of the bone and improves BMD (Perry & Downey, 2011, Kelley, Kelley, & Kohrt, 2013). Furthermore, exercise has been shown to improve balance and mobility in
the older population (Steadman, Donaldson, & Kalra, 2003). A patient-tailored multicomponent exercise programme can reduce falls and fall-related fractures. According to Sherrington et al. (2011) a typical fall prevention exercise programme for community dwelling adults should incorporate the following components: a) exercise sessions should be at least for 2 hours per week providing emphasis to balance exercise and strength training, b) walking session should be incorporated in addition to balance and strength training exercise, c) exercise session should be an ongoing process, d) risk factors such as impaired vision and other comorbidities that cannot be addressed through exercise therapy should be referred to physician for appropriate interventions. Patient education on the significance of healthy lifestyles and environmental modification, use of assistive devices for mobility and advice on wearing anti-slip footwear are various fall and fracture prevention strategies that a physiotherapist is skilled to execute. However, physiotherapist largely focus on fracture care and low priority is given to secondary fracture prevention (Myers & Briffa, 2003). Meyer and Briffa (2003) study show that only 7 % of individuals with colles’ fracture was assessed for subsequent falls risk.

1.4 The Mechanism and Incidence of DRF

The mechanism of injury in a DRF is mostly a fall on an outstretched hand (Sigurdardottir, K, 2014). The forearm is weakest at the distal metaphysis of the radius bone (Sigurdardottir, K, 2014). In a fall on an outstretched hand, the maximum load is transmitted through the distal aspect of the radius causing it to fracture (Sigurdardottir, K, 2014). The incidence of DRF varies according to age, gender and ethnicity. There is a bimodal distribution of DRF with a peak incidence between the age of 18 to 25, largely due to sports-related activities, and above the age of 65 years, largely due to low BMD
and general loss of health and mobility (Milutinovic, Andjelkovic, Palibrk, Zagorac, & Bumbasirevic, 2013). The incidence of DRF is 3 to 5 times higher in females than males after the age of 60 (Brogren et al., 2007; de Putter, 2013; Wilcke et al., 2013). The mean age of DRF event in women is 61 to 69 years and in men is 50 to 55 years (Brogren et al., 2007). Interestingly, DRF shows varying rates of incidence in different parts of the world. The highest rate of DRF has been reported from Scandinavian countries (Wilcke et al., 2013; Brogren et al., 2007). Distal radius fracture is less frequent in Asia than Europe and America (Sebastian & Chung, 2012).

1.5 Classification

DRF follows numerous fracture patterns. Literature presents more than 20 types of classifications for these fractures (Flinkkilä, T., 2004). Some of the oldest classifications clinically used are eponyms (Colles’ fracture, Smiths’s fracture, Barton’s fracture Chauffeur’s fracture, “Die punch fracture”). The typical contemporary classifications are AO classification, Fernandez’ classification, Fragment-specific classification, and Column classification (Flinkkilä, T., 2004). The classification of fractures helps in understanding the severity (Flinkkilä, T., 2004). However, most of the classifications are complex which limits their use in daily clinical practice by clinicians. In comparison, some of the classifications are too simple which compromises the accuracy of relevant information (Flinkkilä, T., 2004). In general, DRF classifications are not useful for prognostic assessments of fracture healing (Flinkkilä, T., 2004).

1.6 Epidemiology

In 2001, 643,000 cases of radius or ulna fracture were reported in the United States (Chung & Spilson, 2001). The survey of the National Hospital Ambulatory Medical Care
(NHAMCS) database showed that 1.5% of the emergency department visits was due to hand and wrist fractures (Chung & Spilson, 2001). In Britain, 71,000 people sustain a distal forearm fracture every year (O'Neill et al., 2001). Moreover, there is an unprecedented growth in the number of older people around the world. In the United States, the number of seniors aged above 60 will increase from the present rate of 20% of the entire population to 27% by the year 2050 (Bloom, Canning, & Lubet, 2015). This will result in an increased health burden and expenditures required within the healthcare system. The high incidence of DRF observed in different parts of the world, and the rapid growth of older adults will double the challenges of the healthcare system and will impact the quality of life of older adults without relevant preventive strategies in place.

The consequences associated with DRF include hours lost from work (MacDermid, Roth, & McMurtry, 2007), functional limitation (Bialocerkowski, 2002), financial burden (Shauver, Yin, Banerjee, & Chung, 2011) and disability. Wrist fracture causes clinically significant functional decline by 48% compared to the individuals without a wrist fracture (Edwards, Song, Dunlop, Fink, & Cauley, 2010). Wrist fracture causes inactivity often leading to dependence especially in frail patients (Vergara et al., 2016). DRF is also associated with shorter lifespan. A study showed the survival rate of DRF patients to be reduced to 57% while healthy individuals of the same age and gender had a survival rate of 71% (Rozental, Branas, Bozentka, & Beredjiklian, 2002). DRF is an early warning sign for future fragility fractures. The risk of subsequent fragility fracture increased to 55% ten years after the initial DRF and by twenty years the incidence is shown to be as high as 80% (Cuddihy, Gabriel, Crowson, O’Fallon, & Melton III, 1999). The risk of subsequent hip fracture in particular was shown to be 5.7 times greater in patients with previous DRF indicating the clinical importance of tracking and preventing fractures.
(Chen et al., 2013). Timely identification and understanding of the risk factors for a DRF in the current and upcoming older population will prevent not only the fracture of the forearm but also other devastating future fragility fractures. Tamblyn (2000) observed 93% of all radius and ulna fractures are due to a fall. There is a vast array of factors that lead to a fall in the older population. However, fallers commonly have poor balance. Ageing also causes increased postural sway (Sullivan, E. V., Rose, J., Rohlfing, T., & Pfefferbaum, A., 2009) and decline in walking capacity (Nordell, Kristinsdottir, Jarnlo, Magnusson, & Thorngren, 2005). A study showed that balance impairment is a significant risk factor for falls among the elderly (Muir, Berg, Chesworth, Klar & Speechley, 2010). Crilly et al. (1987) report that postmenopausal women with colles’ fracture have postural instability. However, there are not many studies examining the postural stability of older adults with DRF. It is crucial to understand the postural stability of DRF patients to develop targeted and relevant risk reduction strategies that are inclusive of all pertinent risk factors. A rapidly growing global aging population, and continuously strained financial resources in the healthcare system warrants an in-depth analysis of most critical risk factors of DRF. Determining the risk factors for fall related to DRF events will enable preventive measures and public health interventions to reduce the rate of DRF globally. Two research questions were developed to understand better the predisposing factors of DRF and the significance of postural instability in contributing to the incidence of DRF.

1.7 Research Questions.

1.6.1 What factors contribute to falls which lead to distal radius fracture?

1.6.2 Is balance a problem in patients with distal radius fracture?
1.8 References


Chen, C., Huang, T., Su, L., Kuo, Y., Wu, S., & Li, C. et al. (2013). Incidence of subsequent hip fractures is significantly increased within the first month after distal radius fracture in patients older than 60 years. *Journal of Trauma and Acute Care Surgery, 74*(1), 317-321. http://dx.doi.org/10.1097/ta.0b013e31824bb325


Flinkkilä, T. Classification of distal radius fracture (2004). In L. M. Hove, T. Lindau, & P. Hølmer, (Eds.), Distal radius fractures: Current concepts (pp. 83-91). Dordrecht: Springer Berlin Heidelberg. doi:10.1007/978-3-642-54604-4


Gudmundsdottir, R., S., The elderly osteoporotic patent (2014). In L. M. Hove, T. Lindau, & P. Hølmer, (Eds.), Distal radius fractures: Current concepts (pp. 241-254). Dordrecht: Springer Berlin Heidelberg. doi:10.1007/978-3-642-54604-4


Sigurdardottir, K. Epidemiology (2014). In L. M. Hove, T. Lindau, & P. Hølmer, (Eds.), *distal radius fractures: Current concepts* (pp. 21-30). Dordrecht: Springer Berlin Heidelberg. doi:10.1007/978-3-642-54604-4


Chapter 2: What Factors Contribute to Falls Which Leads to Distal Radius Fracture?

2.1 Introduction

Distal radius fracture (DRF) is a common, debilitating injury of the upper extremity with a crude incidence of 175.5/100,000 persons in the US alone (Orces & Martinez, 2010). Between 2001 and 2007, the number of older adults (>50 years) who received treatment for forearm and hand fractures increased by 15.2% in US hospitals (Orces & Martinez, 2010).

DRF is prevalent in all age groups and is more widely reported among children, young adults and the elderly (Randsborg et al., 2013; Nellans, Kowalski & Chung, 2012). The cause for DRF is multi-factorial though the factors leading to DRF vary according to the age group. DRF in a young adult is primarily related to sports activities and severe trauma. (Lindau, Aspenberg, Arner, Redlundh-Johnell & Hagberg, 1999). Elderly incur DRF mostly due to low energy trauma (Broadbent, Quaba, Hadjucka & McQueen, 2003). Low energy trauma is caused by a minimal force such as a fall from a standing height. The risk of a fall and sustaining a DRF is influenced by a broad set of health determinants; namely socio-economic, environmental, physical and behavioral factors. The incidence of DRF is four times higher in women than men (O'Neill et al., 2001). The rural population has a lower incidence of DRF compared to the urban population (Diamantopoulos et al., 2012). Environmental factors specifically slippery pathways due to adverse weather conditions are risk factors for DRF (Ali & Willett, 2015). DRF occurs in healthy active individuals (Kelsey et al., 1992). Brisk walking is also associated with DRF (O'Neill, Marsden, Adams, & Silman, 1996). Physical factors such as low BMD,
and poor balance (Crilly et al., 1987) are associated with DRF in elderly individuals. A higher incidence of DRF is associated with low BMD (Mallmin et al., 1992; Kelsey et al., 1992). The frequency of DRF is 8.9 times greater in people with osteoporosis than individuals without osteoporosis (Harness et al., 2012). The after effect of DRF is pain followed by various vocational and functional limitations. Bialocerkowski et al. (2002) have shown that 65% of patients with wrist injuries in general had difficulties with work activities and 54% of them have difficulties with domestic tasks. A subgroup (21%) of patients does not ever recover completely (Földhazy et al., 2007). Understanding the factors leading to a fall in DRF patients may enable effective preventive strategies and reduce the burden of DRF for the individual and the health care system both functionally and financially.

2.1.1 Objective

To describe the factors that lead to a fall in a cohort of patients with DRF, considering the age, gender, mechanism of fracture, work status and patient perceived factors in the cause of the fall.

2.2 Methods

2.2.1 Research Design

A concurrent triangulation mixed method design was used (Creswell & Plano Clark, 2007) to attain a deeper insight into the factors leading to a fall in DRF patients. The goal of the mixed method design was to capture the risk factors for DRF from multiple dimensions by analyzing the quantitative components and thematically exploring the qualitative components. Concurrent triangulation strategy allows for concomitant analysis and comparison of quantitative and qualitative data while further aiding in determining
the degree of convergence and divergence between factors (figure1). Integration of quantitative and qualitative data was done during the interpretation phase.

Quantitative Data                          Qualitative Data

Collection                                Collection

Quantitative Data                          Qualitative Data

Analysis                                  Analysis

Interpretation based on
Quantitative and Qualitative
Results

*Figure 1*: Concurrent Triangulation Design

**SOURCE**: Adopted from Creswell, Planoclarke et al. (2007, pp.63, figure 4.1a)

2.2.2 Quantitative Data

A descriptive analysis of men (n=430) and women (n=1023) who sustained a DRF and reported to fracture clinic was done retrospectively in order to identify the factors of the fall that resulted in a DRF event. Community-dwelling adults with DRF above the age of 18 were included in the study. Participants with cognitive impairments were excluded from the study.

Information about age, gender, work status, mechanism, energy level, site (right/left/both) and calendar month of DRF recorded in the database were gathered and analyzed according to age groups using SPSS version 23 statistical software. Mechanism of DRF refers to various factors that lead to a fall causing a DRF. The identified factors were falls
on ice or snow, other falls (represent falls due to environmental factors and during activities), motor vehicle accidents, industrial accidents and sports injury. The energy level of fractures was classified into low, medium and high energy level of fracture. Low energy level fracture represent falls from a standing height. Medium energy level fractures refer to falls from a greater height such as a fall from a ladder. High energy level fractures refer to fractures caused by motor vehicle accidents, industrial accidents and sports activities. Age groups were categorized into young adults (18 to 24 years); middle-aged adults (25 to 44 years); older adults (45 to 64 years) and seniors (65 years and above). Descriptive statistical analysis was then undertaken.

2.2.3 Qualitative Data

A new cohort of men(n=10) and women(n=19) above the age of 40 (age range: 40 - 75 years) who had sustained a DRF were interviewed about their fall circumstances via phone interviews. Inclusion criteria were: a) men and women who had sustained a DRF by falling, b) above 40 years c) community-dwelling adults and d) fluent in English. The exclusion criteria were: a) participants with neurological conditions and b) physical or mental disability. Each interview was analyzed using a descriptive thematic analysis. The selected patients were contacted over the phone. Participants provided verbal consent before the interview. The interview was 10 to 15 minutes long which was audiotaped and transcribed verbatim. Phone interviews were conducted using the survey developed for the study and self–administered Comorbidity Questionnaire. Questions primarily focused on factors that contributed to falls (see Appendix B). In the first stage, each interview was reread, and the recordings were listened several times to ensure accuracy. In the
second stage, keywords were highlighted, and coding was provided. In the third stage, repeated codes were clustered to capture emergent thematic patterns.

2.2.4 Triangulation of Quantitative and Qualitative Data

Quantitative and qualitative data were analyzed separately and then compared to determine, data convergence and divergence.

2.3 Results

Table 1
*Demographic Characteristics of Participants*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Quantitative Data</th>
<th>Qualitative Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>n = 1454</td>
<td>n = 29</td>
</tr>
<tr>
<td>Men</td>
<td>431(30%)</td>
<td>10</td>
</tr>
<tr>
<td>Women</td>
<td>1023(70%)</td>
<td>19</td>
</tr>
<tr>
<td>Age Range</td>
<td>18 to 89 years</td>
<td>40 to 75 years</td>
</tr>
<tr>
<td>Mean Age±SD</td>
<td>53.5±16</td>
<td>50±6</td>
</tr>
<tr>
<td>Comorbidities</td>
<td>-</td>
<td>51%</td>
</tr>
</tbody>
</table>

2.3.1 Quantitative Analysis

The DRF participants were between the age of 18 to 89 with a mean age of 54. The highest number of DRF was observed among the Older adults (44%) followed by seniors (27%), middle-aged adults (23%) and young adults (6%) (Figure 2).
Overall, the number of DRF was doubled in women (n=1023) compared to men (n=431). In the young adults, the number of DRF was higher in males (58%) compared to females (42%). In the middle-aged adults, the number of DRF did not show any major gender difference. However, in the older adults the number of DRF was almost 3 times greater in females compared to males which further escalated to 6 times greater in females compared to males among the senior group (Figure 3).
2.3.1a. Mechanism of Fracture

Regardless of age, the mechanism of fracture was reported by most patients (76%) to be within “other falls” category (Table 1). Other falls was an umbrella term utilized when falls were due to environmental factors (except fall due to snow specifically) and a fall that occurred during household, vocational, outdoor and leisure activities. In the young adults, “other falls” constituted 73% however, the details regarding these falls was not recorded. In the middle-aged adults, “other falls” chiefly constituted falls while doing outdoor and vocational activities (80%). Among the older adults, “other falls” represented falls due to environmental factors and falls that occurred during household and outdoor activities (75%). The cause for “other falls” among the seniors was mainly due to environmental factors and two specific instances where a knee gave way (76%).

Overall, DRF due to a fall on ice or snow constituted 21% of reported factors. DRF associated with sports injuries and motor vehicle accidents was reported in only 3% and
1% of patients, respectively. Information regarding the mechanism of fracture was missing for 9% of total participants.

Table 2

_Mechanism of Fracture According to Age Group_

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Fall on Ice or Snow</th>
<th>Other Falls</th>
<th>Motor Vehicle Accident</th>
<th>Industrial Accident</th>
<th>Sports Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young Adults</td>
<td>17(20%)</td>
<td>61(73%)</td>
<td>2(2%)</td>
<td>0</td>
<td>4(5%)</td>
</tr>
<tr>
<td>Middle-aged Adults</td>
<td>48(16%)</td>
<td>242(80%)</td>
<td>4(1%)</td>
<td>1(0.3%)</td>
<td>7(2%)</td>
</tr>
<tr>
<td>Older Adults</td>
<td>133(23%)</td>
<td>433(75%)</td>
<td>5(0.9%)</td>
<td>1(0.2%)</td>
<td>8(1%)</td>
</tr>
<tr>
<td>Seniors</td>
<td>83(23%)</td>
<td>276(76%)</td>
<td>4(1%)</td>
<td>0</td>
<td>21(6%)</td>
</tr>
<tr>
<td>Total</td>
<td>281(21%)</td>
<td>1012(76%)</td>
<td>15(1%)</td>
<td>2(0.2%)</td>
<td>40(3%)</td>
</tr>
</tbody>
</table>

_Note_. Young Adults:18-24 years; Middle-aged Adults:25-44 years; Older Adults:45-65 years; Seniors above 65 years.

Overall, low energy level fracture (75%) was predominant in (Figure 4) (Table 2) participants. The energy level of fracture showed contrasting results in males and females. High energy level fracture was predominant in males (62%) compared to females (38%), while low energy level fracture was predominant in females (78%) compared to males (22%).
Figure 4: Overall Energy level of Fracture

Table 3

*Energy Level of Fracture (Low, Medium and High) According to Age Group*

<table>
<thead>
<tr>
<th>Energy Level of Fracture</th>
<th>Young Adults</th>
<th>Middle Adults</th>
<th>Older Adults</th>
<th>Seniors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>33(52%)</td>
<td>140(56%)</td>
<td>350(79%)</td>
<td>242(89%)</td>
</tr>
<tr>
<td>Medium</td>
<td>15(24%)</td>
<td>82(33%)</td>
<td>68(15%)</td>
<td>24(9%)</td>
</tr>
<tr>
<td>High</td>
<td>15(24%)</td>
<td>29(12%)</td>
<td>22(5%)</td>
<td>7(3%)</td>
</tr>
</tbody>
</table>

2.3.1b Work Status

DRF was highest among the employed group (48%) followed by retired group (31%) (Figure 5). Lower number of DRF was observed among the unemployed (3%) and students (3%). The majority of the employed group constituted older adults (54%) and middle-aged adults (35%) (Table 3).
Figure 5: Frequency of DRF According to Work Status

Table 4

Work Status According to Age Group

<table>
<thead>
<tr>
<th>Work Status</th>
<th>Young Adults</th>
<th>Middle-aged Adults</th>
<th>Older Adults</th>
<th>Seniors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employed</td>
<td>45</td>
<td>220</td>
<td>336</td>
<td>20</td>
</tr>
<tr>
<td>Retired</td>
<td>0</td>
<td>1</td>
<td>127</td>
<td>281</td>
</tr>
<tr>
<td>Homemaker</td>
<td>0</td>
<td>15</td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>32</td>
<td>42</td>
<td>12</td>
</tr>
<tr>
<td>Unemployed</td>
<td>3</td>
<td>7</td>
<td>26</td>
<td>4</td>
</tr>
<tr>
<td>Student</td>
<td>28</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
2.3.1c Site of Fracture

A greater proportion of DRF was in the non-dominant hand (53%). Only 1% of participants had bilateral DRF.

2.3.1d. DRF According to Calendar Months

The highest number of DRF was observed in the month of January (15%), followed by an equivalent incidence in the months of December and March (11%). Nine percent of DRF was reported to have occurred in the months of February and June, while the lowest percentage of DRF occurred in July (5%) (Figure 6).

![Figure 6: Frequency of Fracture According to Calendar Months](image)

2.3.2 Qualitative Analysis

DRF resulted from multiple factors. The four main themes developed through thematic analysis can be found below.
Theme 1: Environmental factors

DRF participants (n = 14/29) reported environmental factors such as uneven pavement, snow, waxy floors, poorly fixed rugs, cluttered floors and poor lighting to be the cause for their fall that resulted in a DRF.

“The pavement was uneven.” (Participant 1).

“I slipped on black ice. I was walking the dog it had rained the day before and then froze over night then we had a light snow so it was just a black ice under snow and I couldn’t see it.” (Participant 2)

“Well it was about 2 O’clock in the morning, that doesn’t sound good okay, here is the thing I deliver the newspapers so I am delivering the news papers at 2’O clock in the morning and the place that I was delivering we have to walk up 3 steps but the first step was only about 2 inches, the riser was only 2 inches and I went right into the riser, my hand went out and I hit the riser of the next step with my hand.” (Participant 3).

“I was visiting with my sister in California, and a brand new house and a brand new bathroom and she put on a rug that did not have a backing and I was early in the morning washing my hand and my feet start wander me and I reached the counter my hand was wet and I went down landed on my right hand.” (Participant 4.)

Theme 2: Behavioral factors

Vigorous behaviors such as climbing on a chair for household activities, running down a hill on snowy days were a contributing factors for DRF in 2 of the participants. Three of the participants wore unfitting foot wear that lead to a fall and DRF. Other behavioral
factors such as lack of attention and intoxication lead to fall and fracture in 3 other participants.

“I stepped up on the chair and the chair kind of flipped forward.” (Participant 5).

“I went out for a walk on a spring day and I went down and there was no bump or anything I just finished talking to a lady going along and I discovered after the cast was off and everything I had shoes on that was a designer running shoes, I hardly wore them but I put them on that day, and next time I wore them after I had cast off and I was at gym, I noticed something funny, the sole was coming off from the front.” (Participant 6).

Theme 3: Physical factors

Poor balance resulted in a fall that caused DRF in three of the participants.

“Lost balance when taking shoes off.” (Participant 7).

“Lost balance when trying to sit on the couch.” (Participant 8).

Theme 4: Sports activities

Four of the participants incurred DRF while playing games or sports.

“Fell while skating.” (Participant 9).

“Fell on ice while curling.” (Participant 10).

2.3.3 Triangulation of Quantitative and Qualitative Methods

Risk factors of DRF were very similar when quantitative data and interview data were triangulated. Environmental factors were an overlapping risk factor in quantitative and qualitative components. Behavioral factors were the additional factor that emerged from qualitative interview data.
2.4 Discussion

Risk factors of DRF were very similar when quantitative data and interview data were triangulated. Environmental factors were an overlapping risk factor in quantitative and qualitative components. Behavioural factors were the additional factor that emerged from qualitative interview data. The results demonstrate DRF events occur due to multiple factors. Most of the DRF event was due to environmental factors followed by behavioural factors and occurred while doing activities. The proportion of DRF was higher among females, older adults and employed group. DRF was twice in females compared to males. However, in the 18 to 24 age group men had a higher rate of DRF compared to women.

In the older adult and seniors, the number of DRF was 3 times and 6 times respectively in females compared to males. The majority of the previous studies showed a high rate of DRF in females and low energy level fracture which was associated with lower BMD (Mallmin, Ljunghall, & Naessén, 1992; Oyen et al., 2011). Another study showed that the incidence of DRF was 10 /10,000 population per year at the premenopausal stage which gradually rose to a peak of 120/10,000 population per year in individuals aged above 85(Thompson, Taylor, & Dawson, 2004). Overall, 75% of fracture was a low energy level fracture. The prevalence of osteoporosis is higher in patients with low energy level DRF (Øyen, Rohde, Hochberg, Johnsen, & Haugeberg, 2009, Kanterwitzcz et al., 2002). Fracture preventive strategies prioritizing bone health would reduce the incident rate of DRF (Harness et al., 2012).

The older adult group had the highest number of DRF. An identical number of DRF was observed in the seniors and middle-aged adults and lowest number was recorded in the young adults. A different observation was made by Flinkkila et.al (2010) and Bentohami.
et al. (2014) were the DRF incidence rate increased with age. However, a study from Norway showed a plateau after the age of 60 then there was a decrease in the incident rate of DRF (Hove, Fjeldsgaard, Reitan, Skjeie, & Sörensen, 1995). Between the age of 44 to 65, the adult population are usually more active than the seniors. DRF occurs in individuals who are active with poor bone strength (Kelsey et al., 1992, 2004). Moreover, most of the fracture in our sample of DRF participants occurred while doing household, vocational and outdoor activities which shows that the DRF participants of the current study were active. This notion is further supported by the highest number of DRF observed in the employed group of our sample population. Employed individuals are more active than the retired or unemployed individuals (Van Domelen et al., 2011). Many studies have reported inactivity to be associated with reduced incidence of DRF (Graafmans, Ooms, Bezemer, Bouter, & Lips, 1996; Kelsey et al., 1992). Inactivity might be the reason for the lower proportion of DRF observed in the seniors and unemployed participants of our study. Moreover, 40% of our unemployed participants were disabled and therefore much less likely to be mobile or participating in vigorous activities in which a fall causing a DRF was a possibility.

Greater number of DRF was recorded in the left side (53%). O’Neill et al. (2001) made a similar observation in his study where 55.6% was a left-sided fracture. The majority of people are right-handed. Therefore, the right hand is mostly used for activities or for carrying objects. In an event of fall, an individual is more likely to stretch out the unengaged left hand to prevent a fall thus resulting in its fracture at the distal radius. According to O’Neill (2001), activity enables bone loading which increases the bone strength. The right hand is largely used in day-to-day activities which enables better bone loading and strength in the right hand compared to the left hand.
In the current study, the proportion of DRF remained relatively high from the month of December to March indicating the role of winter seasons in DRF. During the winter months, sidewalks and pathways are often slippery due to snow and ice. Therefore, a fall on the snow, especially with weak bones, may be a contributing factor for DRF leading to its higher proportion during the winter season. This trend has previously been demonstrated within the literature (Giladi et al., 2014; Ali & Willett, 2015; Verma, Lombardi, Chang, Courtney, & Brennan, 2008). Other environmental factors such as black ice, uneven pavement, obstacles and slippery floors were reported by the participants as the cause for their falls in our study.

The qualitative analysis of our sample population captured behavioural factors as an additional risk factor for fall causing DRF. Improper shoes, specifically new shoes and high heeled shoes, were reported to be the cause of a fall by our participants. Lack of attention and engaging in risk taking activities were the other behavioural factors that were reported in our study. A study by Keegan (2004) showed that wearing shoes that were worn less than three times a week, shoes with medium/high or narrow heel increased the risk of distal forearm fracture. Two instances of vigorous activities such as climbing on a chair for household activities and running down the hill resulted in DRF. Vigorous activity is shown to increase the rate of DRF (Keegan, 2004). Only three participants reported a loss of balance to be the cause of the fall that resulted in a DRF. This finding highlights that the DRF population have a relatively good neuromuscular function (Kelsey et al., 1992). Thematic analysis of qualitative interview data showed sports activities to be a contributing factor for DRF in participants aged above 40. DRF is associated with sports activities in young adults (Nellans, Kowalski & Chung, 2012).
Studies examining the association of sports activities with middle and older adults with DRF are limited.

The majority of the participants had comorbidities. Comorbidities might have contributed to a fall. Lawlor (2003) showed that the risk of falling in an individual increased with the number of chronic diseases. However, none of the participants in our study attributed comorbidities to be a contributing factor for their fall. Comorbidities are associated with ageing (Yancik et al., 2007). Elderly people might be associating environmental factors to be the cause for falls to deflect from age-related failing health.

Limitations

BMD, one of the important risk factor for DRF was not measured. Some of the DRF participants were not able to provide a precise reason for a fall which might have obscured important information due to reporting bias. The retrospective description of quantitative data must have caused misclassification.

Strengths

We had participants from wide range of age groups (18 to 89 years). The sample size was relatively large. Mixed method study gave an in-depth understanding of the risk factors of DRF from multiple dimensions. Triangulation of two methodologies provided confirmation and cross-validation of the findings (O’Cathain, A., Murphy, E., & Nicholl, J, 2007).

2.5 Conclusion

DRF occurs largely among active individuals. Environmental and behavioural factors play a role in the DRF events. There was a high number of low energy level fracture. The proportion of DRF was higher in female participants.
2.6 References


Øyen, J., Rohde, G., Hochberg, M., Johnsen, V., & Haugeberg, G. (2011). Low bone mineral density is a significant risk factor for low-energy distal radius fractures in


Chapter 3

Is balance a problem in Patients with Distal Radius Fracture?

3.1 Introduction

Facilitating healthy ageing through active living is important. Distal radius fracture (DRF) can interfere with active living, and may result in a functional decline of the individual (Edwards, Song, Dunlop, Fink, & Cauley, 2010). Fracture of the radius and ulna accounts for 44% of all hand and wrist emergency department visits (Chung & Spilson, 2001). More than 90% of fracture of radius and ulna results from falls (Tamblyn, 2000). The direction of fall determines the site of the fracture. Hip fracture mostly occurs due to a sideways fall while a wrist fracture occurs with a fall in a backwards direction (Nevitt & Cummings, 1993). However, the common mechanism of injury in DRF is a fall on an outstretched hand (Meena, Sambharia, Sharma, & Dawar, 2014).

DRF is associated with multiple factors. These factors can broadly be categorized into demographic, physical, behavioural and environmental factors. DRF rate is shown to increase with age (Flinkkila et al., 2010 and Bentohami et al., 2014). The incidence of fracture is 3 to 5 times higher in women compared to men, especially after the age of 60 (De Putter et al., 2013; Sigurdardottir, Halldorsson & Robertsson, 2011; Wilcke, Hammarberg & Adolphson, 2013). The higher incidence in females appears to be at least in part due to bone demineralization which is more pronounced in women following menopause (Weber-Rajek, Mieszkowski, Niespodziński, & Ciechanowska, 2015 Harness et al., 2012). Evidence indicates that women have a lower trabecular density and more rapid decline in cortical bone thickness after the age of 50 compared to men (Dalzell et al., 2009). This bone micro architectural difference between genders may partially
explain the increased incidence of fracture in females. Physical factors such as poor balance, reduced muscle strength and altered gait patterns predispose a person to falls and fractures (Cebolla, Rodacki, & Bento, 2015). Prior evidence indicates that poor neuromuscular control, which has a detrimental effect on balance, increases the risk of falling (Wilcke et al., 2013). Physical activity can reduce falls and fractures (Pereira, Baptista & Infante, 2013). Consistent with this theory, Diamantopoulos et al. (2012) found that those living in more rural areas had a lower rate of DRF than their urban counterparts that may be partly explained by daily activity level. Behavioural factors such as risk-taking nature, vigorous activity and brisk walking have also shown to result in falls and fractures (Keegan, 2004). The rate of DRF also appears to increase due to environmental factors such as slippery outdoor conditions (Giladi et al., 2014) and winter seasons (Ali & Willett, 2015).

Falls which is a major risk factor for DRF can have multiple causes, but postural instability is assumed to be one of the most critical factor. Studies investigating the association of postural instability with DRF are limited. Postural stability is the ability of an individual to keep their centre of mass (COM) within their base of support (BOS) (Shumway Cook, 1995). A lack of postural stability, characterized by increased postural sway, leads to falls in the elderly (Melzer, 2004). Somatosensory, visual and vestibular systems maintain COM within the BOS (Shum-way Cook, 2000). Defects in any of these posture control components will result in an increased risk of falls (Winter, 1990). A study on postural stability and Colles’ fracture indicated that subjects with Colles’ fracture had greater postural sway compared to their control group (Crilly et al., 1987).

Understanding whether postural instability is a major risk factor for a fall in the DRF population may help focus DRF prevention strategies. The hypothesis was the older
adults with DRF have postural instability and are at higher risk of fall caused by poor balance compared to age-matched individuals without a DRF.

3.1.1 Objectives

The purpose of the study was to determine if there were differences in postural stability and fall risk score in DRF participants compared to age and gender-matched elderly without a DRF. Secondary purposes were to explore changes in postural stability and fall risk score over the year following a DRF controlling for age and gender and to determine the significance of age and gender as a between-subject factor for postural stability and fall.

3.2 Method

3.2.1 Research Design

Prospective cohort study.

3.2.2 Ethics

The study was reviewed and approved by the ethics board of the University of Western Ontario.

3.2.3 Participants

The sample was composed of 137 participants (age range: 54 to 78 years) with acute distal radius fracture. Patients attending the orthopaedic clinic with acute DRF were invited to participate in the study and consent was obtained from willing volunteers. Participants who had a history of humeral, hip, or vertebral fractures and with neurological disorders were excluded.
3.2.4 Procedure

Postural stability and fall risk assessment was measured using a Biodex Balance System (BBS) (Appendix C). BBS has demonstrated excellent reliability in measuring fall risk and postural stability in the older population (Parraca et al., 2011). Baseline assessment was taken within the first week of fracture, followed by subsequent assessments at 3 months, 6 months, and 1 year. A standardized assessment protocol, done by a single assessor minimized bias. BBS is a multi-axial device that can objectively estimate dynamic postural stability. The device consists of a software interfaced circular platform that can move in the anterior-posterior and medial-lateral direction simultaneously (Arnold & Schmitz, 1998).

The maximum tilting capacity of the platform is 20 degrees in all directions. The participants try to keep the platform level so that the participant’s centre of gravity is over the base of support. BBS measures the tilt about each axis and calculates a medial-lateral stability index (MLSI), anterior-posterior stability index (APSI) and overall stability index (OSI). These indexes are measured in degrees and represent deviations from level platform position (horizontal). That is the displacement of the center of mass around the centre of the platform (0 points). Anterior-posterior and medial-lateral stability indexes represent platform displacement in sagittal and frontal planes respectively. The formula to calculate the anterior-posterior (APSI), medial-lateral (MLSI) and overall (OSI) stability index is shown below

\[
\text{APSI} = \sqrt{\frac{\sum (0-Y)^2}{\text{Number of Samples}}}
\]

(Y is the total deviation from horizontal along anterior-posterior directions)
MLSI = \sqrt{\frac{\sum (0-x)^2}{\text{Number of Samples}}} 

(X is the total deviation from horizontal along medial-lateral directions)

OSI = B \sqrt{\frac{\sum (0-x)^2 + \sum (0-y)^2}{\text{Number of Samples}}} 

The platform has 8 levels of stability (Arnold & Schmitz, 1998). Stability level 8 is the most stable condition. For this study, the initial platform stability was set at 6 and the final platform stability was set at 2. Once the platform stability is set and the assessment is initiated the platform is released to the pre-set stability level. The participant is required to maintain the platform level. The deflection of the platform from zero points, in the anterior-posterior (APSI) and medial-lateral (MLSI) directions, are recorded, and the BBS device calculates the APSI, MLSI and OSI. Higher scores on the stability indexes indicate decreased postural stability. The BBS also measures the time spent in each concentric zone and quadrant. Each concentric circle (zones) represents the angular displacement of COM from the centre of the foot platform (Arnold & Schmitz, 1998). There are four zones namely: Zones A (0-5), Zone B (6-10), Zone C (11-15) and Zone D (16-20). A person with good postural stability spends the majority of time in Zone A. As postural stability decreases the angular displacement increases and the person spends more time in Zones B, C or D.

To record fall risk score, participants stood on the BBS platform with their feet positioned at shoulder width equidistant from the vertical and horizontal line that separate the platform into four quadrants. Participants were asked to balance themselves so as to keep the indicator on the BBS display screen at the centre. Three practice trials with 10 seconds of a break between the trials were performed followed by the main trial from
which data were recorded. The BBS fall risk index measurements obtained for participants with DRF were categorised into average, above and below average compared to the BBS normative value. Participants aged above 65 were also compared to the BBS fall risk index and postural stability score of a sample of healthy Canadian seniors. The BBS fall risk index and postural stability score for healthy Canadian seniors were acquired through a cohort study that investigated community-dwelling healthy seniors (Song, MacDermid & Grewal, 2013). The test procedure for postural stability is similar to the fall risk test. In the postural stability test, BBS generated a stability index value by assessing the degree and period that the platform was off level.

A total of 188 patients enrolled in the study. However, 15 participants (10 females and 5 males) who initially consented did not provide baseline data. Moreover, 36 patients participated only in the initial assessment. These 51 participants were excluded from the analysis. Thirteen participants failed to come for the follow-up assessment at 6 or 12 months. The last observation carried forward method was used to impute these missing values. Finally, a total of 137 participants were analyzed for postural stability and fall risk in the BBS system.

3.2.5 Statistical Analysis

SPSS version 23 was used to analyze the data. Categorical data are presented as percentage. A paired t-test was used to analyze the difference in risk of fall and postural stability between the sample of healthy Canadian seniors and the participants with DRF aged above 65 (n = 46; Men:13; Women:33). The samples were matched according to age and gender. The change in postural stability and BBS fall risk score over the year controlling for age and sex was determined using a
general linear model repeated measure ANOVA. The dependent variable (BBS fall risk index and postural stability) was measured on a continuous scale. Data violated the assumption of sphericity and therefore Greenhouse-Geisser correction procedure was used to interpret the result. Comparison between age group (above and below 65 years) was determined using a general linear model repeated measure ANOVA of time with age group (above and below 65 years) as between subject factor. Similarly, gender comparison was analyzed using a general linear model repeated measure ANOVA of time with sex as a between-subject factor.

3.3 Results

3.3.1 Demographics.

The sample consisted of 137 participants (19 men and 118 women) with the mean age of 61 years ±7 (age range: 54-78 years).

3.3.2 Fall Risk (BBS Fall Risk Index)

A comparison of the mean falls risk score of DRF participants with the BBS normative data showed that only 12% (n = 16) of participants with DRF scored worse than the normal healthy individuals. Participants who scored within the BBS normal range was 44% and another 44% of participants scored above the BBS system normative value (Table 4). A sample of healthy seniors from the Canadian population scored higher (M_{Fall risk} = 4.40; SD=2.3) than DRF participants aged above 65 (average mean of the follow-up assessment was 2.30 and SD=1.3, t (45) = -5.6, P<0.05). A higher score in postural stability and fall risk denotes poorer balance and a greater likelihood of fall.
Table 5

*Fall Risk Score at Different Time Point Compared to the BBS Normative Data*

<table>
<thead>
<tr>
<th>Time</th>
<th>Better than Average</th>
<th>Average</th>
<th>Worse than Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Week</td>
<td>54 (39%)</td>
<td>64 (47%)</td>
<td>19 (14%)</td>
</tr>
<tr>
<td>3 Months</td>
<td>65 (47%)</td>
<td>57 (42%)</td>
<td>15 (11%)</td>
</tr>
<tr>
<td>6 Months</td>
<td>62 (46%)</td>
<td>60 (44%)</td>
<td>14 (10%)</td>
</tr>
<tr>
<td>1 Year</td>
<td>61 (45%)</td>
<td>59 (43%)</td>
<td>17 (12%)</td>
</tr>
<tr>
<td>Mean</td>
<td>61 (44%)</td>
<td>60 (44%)</td>
<td>16 (12%)</td>
</tr>
</tbody>
</table>

*Notes.* BBS: Biodex Balance System

3.3.3 Postural Stability

A comparison with the age dependent BBS normative data showed that the DRF participants scored within the BBS normal range (Table 5). A sample of age and sex matched healthy seniors from the Canadian population scored higher (*M* Postural stability = 3.6°; SD = 1.6) compared to DRF participants aged above 65 (average mean of the follow-up assessment was 2.2° and SD = 1.1, *t* (45) = -5.2, *P*<0.05).

3.3.4 BBS Zones

DRF participants spent 92% (95% CI: 90.5 to 94.2) to 94% (95% CI:91.6 to 95.7) of their time in Zone A. While, healthy people spend 85% of the time in zone A (Arnold, 1998).
### Table 6

**BBS Fall Risk Index and Postural Stability Adjusted Mean Over Time**

<table>
<thead>
<tr>
<th>Time</th>
<th>Fall Risk</th>
<th>Std. Error</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>week 1</td>
<td>2.2°</td>
<td>0.1</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Months 3</td>
<td>2.0°</td>
<td>0.1</td>
<td>1.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Months 6</td>
<td>1.9°</td>
<td>0.2</td>
<td>1.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Year 1</td>
<td>2.1°</td>
<td>0.2</td>
<td>1.9</td>
<td>2.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postural Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
</tr>
<tr>
<td>2.2°</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>1.9</td>
</tr>
<tr>
<td>2.4</td>
</tr>
<tr>
<td>Months 3</td>
</tr>
<tr>
<td>2.0°</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>1.8</td>
</tr>
<tr>
<td>2.2</td>
</tr>
<tr>
<td>Months 6</td>
</tr>
<tr>
<td>1.9°</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>1.8</td>
</tr>
<tr>
<td>2.2</td>
</tr>
<tr>
<td>Year 1</td>
</tr>
<tr>
<td>2.0°</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>1.8</td>
</tr>
<tr>
<td>2.2</td>
</tr>
</tbody>
</table>

**Notes.** Fall risk normal value:1.4°-3.4° (54-71 age group); 1.9°-3.5° (72-89 age group).

Postural stability normal value:1.4°-3.4° (54-71 age group); 1.9°-3.5° (72-89 age group).

### 3.3.5 Change in Postural Stability and Fall Risk Index Over the Year Following a DRF

A general linear model repeated measure ANOVA determined, there was no statistically significant change in BBS fall risk index (F (2.7,364) = 1.1, P > 0.05) (Table 6) and postural stability score (F (2.6, 342.7) = 1.4, P >0.05) (Table 7) over the year following DRF (Table 5). There was no statistically significant interaction between follow up time with age and gender.
Table 7

*BBS Fall Risk Index Tests of Within Subject Effects Controlling for Age and Gender*

<table>
<thead>
<tr>
<th>Source</th>
<th>Epsilon Type III</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>sig</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>Greenhouse</td>
<td>1.1</td>
<td>2.7</td>
<td>0.4</td>
<td>1.1</td>
<td>0.4</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>-Geisser</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>time * b_age</td>
<td>Greenhouse</td>
<td>0.8</td>
<td>2.7</td>
<td>0.3</td>
<td>0.8</td>
<td>0.5</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>-Geisser</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>time * b_sex</td>
<td>Greenhouse</td>
<td>0.4</td>
<td>2.7</td>
<td>0.1</td>
<td>0.4</td>
<td>0.7</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>-Geisser</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error (time)</td>
<td>Greenhouse</td>
<td>133.2</td>
<td>364</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05. **p <.01
Table 8

*BBS Postural Stability Tests of Within Subject Effects Controlling for Age and Gender*

<table>
<thead>
<tr>
<th>Source</th>
<th>Epsilon Type III</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of Squares</td>
<td>df</td>
</tr>
<tr>
<td>time</td>
<td>Greenhouse 1.1</td>
<td>2.6</td>
</tr>
<tr>
<td>b_age</td>
<td>-Geisser</td>
<td>2.6</td>
</tr>
<tr>
<td>b_sex</td>
<td>-Geisser</td>
<td>2.6</td>
</tr>
<tr>
<td>Error</td>
<td>Greenhouse</td>
<td>100.76</td>
</tr>
</tbody>
</table>

*p<.05. **p <.01

3.3.5 Comparison Between DRF Participants Aged Below and above 65

BBS fall risk index test score for patients grouped below 65 (M_{Fall Risk}=1.9°; 95% CI:1.7 to 2.1) were significantly (P<0.05) lower than the patients grouped above 65 years of age (M_{Fall Risk}=2.3°; 95% CI:2 to 2.5) (Table 8 and 9).

There was no statistically significant (P>0.05) difference in postural stability score between the below (M_{postural stability} = 1.9°; 95% CI:1.7 to 2.1) and above 65 age group (M_{postural stability} = 2.2° 95% CI 2 to 2.5) (Table 8 and 10).
Table 9

*Fall Risk and Postural Stability Mean Score by Age Group*

<table>
<thead>
<tr>
<th>Age group</th>
<th>Fall Risk 95% Confidence Interval</th>
<th>Postural Stability 95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 65</td>
<td>1.9° (1.7-2.1)</td>
<td>1.9° (1.7-2.1)</td>
</tr>
<tr>
<td>Above 65</td>
<td>2.3° (2.0-2.7)</td>
<td>2.2° (2.0-2.5)</td>
</tr>
</tbody>
</table>

Notes. Fall risk normal value: 1.4°-3.4° (54-71 age group); 1.9°-3.5° (72-89 age group);
Postural stability normal value: 1.4°-3.4° (54-71 age group); 1.9°-3.5° (72-89 age group).

Table 10

*Test of Fall Risk Between - Subjects Effects by Age Group (above and below 65)*

<table>
<thead>
<tr>
<th>Type III</th>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>sig</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>2210.994</td>
<td>1</td>
<td>2210.994</td>
<td>469.123</td>
<td>.000</td>
<td>.777</td>
</tr>
<tr>
<td></td>
<td>Age group</td>
<td>21.961</td>
<td>1</td>
<td>21.961</td>
<td>4.660</td>
<td>.033*</td>
<td>.033</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>636.261</td>
<td>135</td>
<td>4.713</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05. **p <.01
Table 11

Tests of Postural Stability Between - Subjects Effects by Age Group (Above and Below 65)

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>sig</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td></td>
<td>2132.938</td>
<td>1</td>
<td>2132.938</td>
<td>583.545</td>
<td>.000</td>
<td>.812</td>
</tr>
<tr>
<td>age group</td>
<td></td>
<td>11.867</td>
<td>1</td>
<td>11.867</td>
<td>3.247</td>
<td>.074</td>
<td>.023</td>
</tr>
<tr>
<td>Error</td>
<td></td>
<td>493.444</td>
<td>135</td>
<td>3.655</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05. **p <.005

3.3.6 Comparison Between Gender

Males demonstrated statistically significant (P<0.05) higher BBS fall risk mean scores and postural stability scores compared to females (P<0.05) (Table 11, 12 and 13) demonstrating poor balance compared to females.
Table 12

**Fall Risk and Postural Stability Mean by Gender**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Fall Risk Mean</th>
<th>Standard Error</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3.2°</td>
<td>0.2</td>
<td>2.7 - 3.6</td>
</tr>
<tr>
<td>Female</td>
<td>1.9°</td>
<td>0.1</td>
<td>1.7 - 2.1</td>
</tr>
</tbody>
</table>

Postural Stability Mean

<table>
<thead>
<tr>
<th>Gender</th>
<th>Fall Risk Mean</th>
<th>Standard Error</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3.0°</td>
<td>0.2</td>
<td>2.6 - 3.4</td>
</tr>
<tr>
<td>Female</td>
<td>1.9°</td>
<td>0.1</td>
<td>1.7 - 2.1</td>
</tr>
</tbody>
</table>

*Notes.* Fall risk normal value: 1.4°-3.4° (54-71 age group); 1.9°-3.5° (72-89 age group); Postural stability normal value: 1.4°-3.4° (54-71 age group); 1.9°-3.5° (72-89 age group).

Table 13

**Test of Fall Risk Between - Subjects Effects by Gender**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>sig</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1602.355</td>
<td>1</td>
<td>1602.355</td>
<td>389.849</td>
<td>.000</td>
<td>.743</td>
</tr>
<tr>
<td>b_sex</td>
<td>103.345</td>
<td>1</td>
<td>103.345</td>
<td>25.144</td>
<td>.000**</td>
<td>.157</td>
</tr>
<tr>
<td>Error</td>
<td>554.876</td>
<td>135</td>
<td>4.110</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05, **p < .01
Table 14

*Test of Postural Stability Between - Subjects Effects by Gender*

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>sig</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1482.309</td>
<td>1</td>
<td>1482.309</td>
<td>462.256</td>
<td>.000</td>
<td>.774</td>
</tr>
<tr>
<td>b_sex</td>
<td>72.408</td>
<td>1</td>
<td>72.408</td>
<td>22.580</td>
<td>.000**</td>
<td>.143</td>
</tr>
<tr>
<td>Error</td>
<td>432.903</td>
<td>135</td>
<td>3.207</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05. **p <.01

3.4 Discussion

Participants with DRF did not exhibit excessive postural instability or risk of a fall due to poor balance compared to the normal subjects of the same age group. The BBS fall risk index and postural stability test scores did not show any significant difference in the year following DRF. This is consistent with a cohort study that showed the health status, neuromuscular function and physical activity of women with lower forearm fracture to be similar or better than the women of the same age group (Kelsey et al., 1992). On the contrary, a systematic review on balance impairment as a risk factor for fall in community-dwelling older adults showed an overall risk value of RR 1.42 and OR 1.98 (Muir, Berg, Chesworth, Klar & Speechley, 2010). However, this study examined the association of balance with falls rather than DRF. On the other hand, Crilly et al. (1987) in his study of 19 postmenopausal women with Colles’ fracture, found that the subjects have not only a reduction in bone mass but also a significant increase in postural instability. Individuals with DRF are generally active (Kelsey et al., 1992) which helps in maintaining balance. Active people can break a fall on an outstretched hand which is a
quick protective reaction to prevent a fall. A fall on an outstretched hand increases the rate of DRF (Kelsey & Samelson, 2009). Therefore, other risk factors for DRF such as environmental factors, behavioural factors and intrinsic factors such as bone health and other health conditions need to be considered.

The incidence of DRF is higher in females than males (Brogren, Petranek, & Atroshi, 2007). The majority of the participants in our study were women (87%). Women are more prone to osteoporosis than males (Cawthon, 2011). Early detection of osteoporosis and prompt intervention might be an efficient strategy for reducing the incidence of DRF (Harness et al., 2012). A high female incidence of DRF could also be attributed to the normal bone structural differences in females and males. A population-based study on bone microarchitecture in normal population showed a lower trabecular bone density, cortical thickness in females than males (Dalzell et al., 2009). After the age of 50, a faster decline in cortical density and thickness was observed in women (Dalzell et al., 2009). Behavioural factors such as walking speed (Quach et al., 2011) and vigorous activities contribute to postural instability and falls irrespective of intrinsic balancing ability. A modest physical or leisure activity is preventive against DRF (Mallmin, Ljunghall, Persson & Bergström, 1994). Keegan (2004) has shown the association of vigorous activities with DRF (OR: 1.9, 95% CI: 1.3 to 2.9).

Comorbidities have detrimental effects on musculoskeletal health which can predispose a person to falls and fractures. Comorbidities such as circulatory disorders, chronic obstructive pulmonary disease, and arthritis are significant predictors of falls (Lawler, 2003). A study on older people with distal forearm fractures showed that more than half the patients were on medical treatment for chronic ailments (Nordell, Kristinsdottir, Jarnlo, Magnusson & Thorngren, 2005). Locomotor problems especially
back pain, hip and knee conditions were exhibited by 55% of the participants with distal forearm fracture and one-quarter of the participants had dizziness (Nordell et al., 2005). The BBS can assess only some of the intrinsic factors leading to postural instability and falls. Environmental factors such as slippery floors, snow, obstacles, poor lightings are examples of extrinsic factors that could result in a fall. DRF exhibits seasonal variation with a peak incidence in the winter season. On a typical winter day, the incidence of DRF is 2.5 (95% CI, 1.6 to 4) times higher than non-winter days (Flinkkila et al., 2010; Giladi et al., 2014). A systematic review on the effect of weather on trauma showed an increased rate of DRF on snowy days (Ali & Willett, 2015).

Patients aged above 65 scored higher on BBS fall risk index and postural stability test compared to those aged below 65. The fall risk index showed a significant difference between age group (below and above 65 years) However, there was no statistically significant difference in the postural stability score between below and above 65 years. Males showed statistically significant higher postural stability and BBS fall risk index scores compared to the females indicating poorer balance in males than females. However, the higher BBS fall risk index score and postural stability scores obtained for male participants were within the normal range. In a study on gender difference in platform measure of balance in rural community-dwelling elders (n=343), men demonstrated significantly higher postural sway under closed and open eye condition compared to females (Masui et al., 2005). However, Overstall (1997) and Sackley and Lincoln (1991) found that women swayed more when compared to men. There were only 19 male participants in our study which does not provide sufficient power to support the observation.
3.4.1 Limitations

The BBS inbuilt normative data is based on the US population and the sampling method is unknown. Thus the validity of this cross-population comparison is uncertain. However, our participants aged above 65 were also compared to a sample of healthy Canadian seniors. Other risk factors for DRF such as osteoporosis, comorbidities, environmental and behavioural factors were not analysed in this study. BBS calculates fall risk related to postural instability and does not represent the general fall risk factors. The last observation carried forward method was used to impute the data which might have made the results very conservative.

3.4.2 Strengths

The study was done on relatively large (137) sample. There were very few (10%) dropouts in the follow-up assessment. The follow-up assessment dates were intentionally chosen to match with the participant’s clinical appointments to minimise dropouts. Test-retest reliability of the BBS is known to be good (Parraca et al., 2011). The protocol was standardised, and a single assessor performed the tests which controlled for systematic errors.

3.4.3 Implications

A minority of (12%) DRF patients had poor balance. Therefore, a general balance training exercise to protect against fall and fracture is recommended only for those with the compromised balance rather than the entire DRF patients. Screening must consider multiple risk factors.
3.4.4 Research Recommendation

Further studies comparing the postural stability of community-dwelling male and female elders are necessary. Studies examining the various risk factors of a DRF patients are required.

3.5 Conclusion

This study found that only a minority of DRF participants had postural instability when compared to published normative values. There was no change in postural stability or fall risk index in the year following fracture signifying no deterioration of postural stability due to fracture. Screening for elderly patients at risk of DRF must consider multiple risk factors. Risk factors such as lower BMD, risk behaviours and environmental factors may be alternative factors to consider in secondary prevention.
3.6 References


http://dx.doi.org/10.1093/ageing/16.3.133

Bone micro-architecture and determinants of strength in the radius and tibia: age-related changes in a population-based study of normal adults measured with high-resolution pQCT. *Osteoporosis International*, 20(10), 1683-1694.
http://dx.doi.org/10.1007/s00198-008-0833-6


http://dx.doi.org/10.1016/j.injury.2012.10.025


http://dx.doi.org/10.1007/s00198-010-1463-3


http://dx.doi.org/10.1007/s11914-009-0022-3

http://dx.doi.org/10.1136/bmj.327.7417.712


http://dx.doi.org/10.1016/j.archger.2005.02.003


http://dx.doi.org/10.1136/bmj.1.6056.261

http://dx.doi.org/10.4100/jhse.2011.62.25

http://dx.doi.org/10.3109/09638288.2013.782355

http://dx.doi.org/10.1111/j.1532-5415.2011.03408.x

http://dx.doi.org/10.1177/026921559100500302


Chapter 4: Discussion

The objective of this thesis was to determine the predominant risk factors of DRF in community-dwelling adults in order to inform relevant preventive strategies. Two research questions were developed:

1) What factors contribute to falls which leads to distal radius fracture?

   The objective of this study was to describe the factors leading to a fall in a cohort of patients with DRF considering age, gender and work status and to describe factors patients consider to have caused a fall. A mixed method analysis was done to describe the nature of fall in DRF patients.

2) Is balance a problem in patients with DRF?

   A one-year prospective cohort study of postural stability and fall risks of patients (n = 137) with acute DRF was conducted. The objective was to determine if the postural stability of DRF patients differed from age and gender-matched norms; to identify any change in postural stability and fall risk in the year following a DRF and to determine the significance of age and gender.

   Our studies showed that the risk factors for DRF are multifactorial. However, environmental factors were observed to be a predominant determinant of a DRF event followed by behavioural factors. The other factors that was observed to be associated with DRF were activities and winter months. Our second study showed that postural stability in patients who had experienced a recent DRF was largely normal compared to normative values. Only a minority of DRF patients (12%) exhibited fall risk associated with postural instability.
Physical activity maintains neuromuscular function, which may be protective against loss of balance. This has been supported by our study results where the majority of our participants incurred DRF while doing activities. Majority of our participants had normal postural stability. Environmental factors have been shown previously to contribute to one-third of falls in community-dwelling elders (Tinetti, Speechley, & Ginter, 1988). Environmental hazards are a major risk factor for falls in vigorous elderly adults (Speechley & Tinetti, 1991). Similarly, another study showed that extrinsic factors are a predominant risk factor for falls in healthy active members of the elderly group (Berg, Cassells, & Stokes, 1992). This indicates DRF occur mainly due to environmental factors and in patients who are active. Therefore, environmental modification may be pivotal in lowering the rate of DRF and may be a critical educational component to future preventive strategies employed by physicians and public health efforts.

Environmental factors combined with certain behavioural factors increases the risk of fall and injuries in the elderly population. Furthermore, individuals with risk-taking behaviour are more likely to engage in activities such as climbing on unsafe supports (Lord, 2006) and brisk activities which are beyond the physical competence of an individual. A study has shown the association between the tendency to fall and type A behavior pattern among community-dwelling men aged above 60 years (Zhang, Ishikawa-Takata, Yamazaki, & Ohta, 2004). Similarly, in our study, some of the behavioral factors reported by the participants to be the cause for DRF were: climbing over poorly supported chair, running down the hill on a snowy day, lack of attention while walking, intoxication and wearing new or high heeled footwear. Vigorous activities and wearing unaccustomed footwear increases the risk of DRF (Keegan, 2004). The risk of fall has a positive association with the heel height of the footwear (OR =1.9, 95% CI 0.8–4.7) (Tencer et al.,
A greater contact of the surface of the sole with the ground is associated with lower risk of falls (Tencer et al., 2004). A proper footwear with lower heel height and larger contact surface may reduce the number of falls and fractures associated with it. An individual’s ability to negotiate environmental hazards and the capacity to undertake risky activities becomes more challenging with the natural aging process compared to younger people. Patient education strategies emphasizing on environmental and behavioural modifications may prove to be effective. Teaching the seniors about the age-related changes in the body function and the significance of taking precautions regarding careful footsteps and activities are important. Following safety measures in day-to-day activities and avoiding hasty work culture is a necessity in community-dwelling seniors.

In both of our studies, a large proportion of patients who had experienced a DRF event were females. It is known that women are more prone to osteoporosis than men (Ralston, 2006). The low energy level (74%) fracture was also predominant in our study. Patients with low energy fracture often have lower BMD (Hung, Wu, Leung, & Qin, 2005) and lower BMD is shown to increase the risk of forearm fracture (Nguyen et al., 2001)

Our findings highlight that preventive strategies for DRF should focus primarily on environmental and behavioral factors without compromising optimal active lifestyle and independence of the elderly population. Intervention to enhance postural stability must be focused on those patients with compromised balance rather than the entire DRF patients. Preventive strategies should be implemented at multiple levels. A prevention strategy with the patient partnership where patients are actively involved in the identification of risk factors enables compliance of prevention strategies. Proper fixing of rugs, clearing the cluttered objects in the indoor and outdoor areas, taking caution while walking on the
uneven pavement and slippery pathways are some of the preventive strategies that can be executed at the patient level. A home safety assessment enhances identification and modification of home hazards which would play a critical role in fall reduction arising from indoor environmental factors (Peel, Steinberg, & Williams, 2000).

Walking speed, one of the behavioral risk factors is associated with increased risk of fall (Quach et al., 2011) and DRF (O’Neill, T., Marsden, D., Adams, J., & Silman, A., 1996). Slowing down the pace of movement of community dwelling elders is a very simple, economical preventive strategy. Avoidance of activities beyond the physical compliance of the elderly may help in lowering the rate of DRF. At the healthcare system and care provision level health care workers must function to be a knowledge broker and be empowered to teach and facilitate prevention measures against the risk factors of DRF. Physiotherapist with their knowledge in neuromuscular, bone health and fracture preventive measures are ideal health care workers to implement and promote fall and fracture prevention strategies. Nevertheless, these prevention strategies should not be limited at patient or clinician level. A broader spectrum incorporating governmental sectors are mandatory in eliminating outside environmental risk factors such as uneven and slippery pathways, change in level at public places and unmarked steps.

4.1 Limitations

Our studies were not without limitations. Qualitative interview data might have had reporting bias. The retrospective analysis of quantitative data must have introduced information bias as the researcher has to rely on the information collected by others. The last observation carried forward method of imputation might have made the result very conservative. Bone mineral density of our study population was not analyzed. The study
was done on community-dwelling elders, and therefore, the results might not be applicable for nursing home residents.

4.2 Strengths

Our study population was relatively large. The study examined the risk factors of DRF both subjectively and objectively thus providing the depth and the breadth of DRF risk factors. Our study provided an opportunity to highlight the risk factors of DRF in a wide range of age group (18 to 89 years).

4.3 Implications

These findings have a broad spectrum of implications at both clinical and non-clinical levels. The risk factors and preventive strategies of DRF should be incorporated into clinical practice guidelines across disciplines. Physiotherapists should be trained in the quick assessment of DRF risk factors and application of preventive strategies. Due to the multifaceted nature of DRF risk factors, clinicians should be empowered to develop and implement a patient-tailored preventive strategy. Policy makers at governmental, provincial, institutional and community levels should incorporate the preventive strategies of DRF risk factors highlighting the significance of environmental and behavioural factors. A rigorous knowledge translation initiatives targeting the active elderly population will enable an efficient implementation of a preventive strategy in the population who is now at greatest risk of a DRF. Local community organisations such as religious and socialisation centres should work as the knowledge brokers. This would ensure an efficient dissemination of preventive measures of DRF across all social levels.
4.4 Directions for Future Research

4.4a. Multiple postural stability assessment tests of DRF patients are recommended to further validate our findings.

4.4b. A study examining the effect of modification of environmental and behavioural risk factors on the rate of DRF among community-dwelling elders is important.

4.5 Conclusion

Environmental factor plays a substantial role in the incidence of DRF. Postural instability is not a major factor for DRF but for a minority of DRF patients (12%). DRF occurs in the active seniors predominantly in females with the highest number occurring in older adults (44 to 65 years). Watching the footsteps, eliminating indoor and outdoor environmental hazards, avoiding activities beyond the physical competence of an individual is a simple, economic intervention that can drastically lower the number of DRF.
4.6 References


Appendix A: Ethics Approval

Research

Western

Principal Investigator: Dr. Joy MacDermid
Review Number: 10492
Review Level: Full Board
Approved Local Adult Participants: 195
Approved Local Minor Participants: 0
Protocol Title: Distal Radius Fracture prospective database 50-80 years old: Overview of Identification of Risk of Adverse Activity Transition Following a Distal Radius Fracture.
Department & Institution: Surgery, University of Western Ontario
Sponsor: Canadian Institutes of Health Research

Ethics Approval Date: January 20, 2012
Ethics Expiry Date: November 30, 2014

Documents Reviewed & Approved & Documents Received for Information:

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Comments</th>
<th>Version Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter of Information &amp; Consent</td>
<td>Including all instruments listed in section 6.1</td>
<td>2011/12/10</td>
</tr>
</tbody>
</table>

This is to notify you that the University of Western Ontario Health Sciences Research Ethics Board (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans and the Health Canada/GCH Good Clinical Practice Practices: Consolidated Guidelines, and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced study on the approval date noted above. The membership of this HSREB also complies with the membership requirements for REBs as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB’s periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWU Updated Approval Request form.

Member of the HSREB that are named as investigators in research studies, or declare a conflict of interest, do not participate in discussions related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The UWO HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00009040.

Signature

Ethics Office to Contact for Further Information

The University of Western Ontario
Office of Research Ethics
Support Services Building Room 5160 • London, Ontario • CANADA • N6G 1C9
Ph: 519-661-3036 • Fax: 519-850-2466 • ethics@uwo.ca • www.uwo.ca/research/ethics

This is an official document. Please retain the original in your files.
## Appendix B: Assessment Forms

### Distal Radius Fracture: The Environmental Causes – Semi-Structured Interview

**Guide**

<table>
<thead>
<tr>
<th>This short survey is regarding distal fractures and falls.</th>
</tr>
</thead>
</table>

1. How did you fall?

2. What things do you think contributed to your fall?

   \textit{Was weather a factor?}

   \textit{Were you participating in any physical activities?}

3. Were there any safety issues that caused you to fall?

   \textit{Were there any obstacles in your way?}

   \textit{Was the floor recently waxed or wet?}

   \textit{Were all mats, rugs, carpets secured?}

   \textit{Were you wearing proper footwear?}

   \textit{Did you experience a fall from a height, if so describe?}

   \textit{Was there adequate lighting?}

   \textit{Were there any liquid substances on the floor?}

4. What could be fixed to prevent your fall from happening again to you or to other people?

   \textit{Are there any safety measures that can be taken to prevent you from falling again?}

5. What have you, if anything, done to change the likelihood of falling again?

6. How many times have you fallen since?

7. Have you experienced a near fall? (e.g. slip, trip, stumble or bumped against a wall?)

<table>
<thead>
<tr>
<th>Gender: …. Date of birth:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current body weight: ….. kg.  Height:….. cm.</td>
</tr>
<tr>
<td>Date:…. ID code………….</td>
</tr>
</tbody>
</table>
The Self - Administered Comorbidity Questionnaire

Instructions:

The following is a list of common health problems. Please indicate if you currently have that problem listed in the first column. If you do not have that problem skip to the next problem.

If you do have the problem, please indicate in the second column if you receive medications or some other types of treatment for the problem.

In the third column indicate if the problem limits any of your activities. Finally, indicate all medical conditions that are not listed, as “other medical problems”, and list them at the end of the page.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Do you have the problem?</th>
<th>Do you receive treatment for it?</th>
<th>Does it limit your activities?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High blood pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulcer or stomach disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kidney disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Condition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anemia or other blood disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osteoarthritis, degenerative arthritis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other medical problems</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Please list other medical problems:**

Scoring No = 0 Yes = 1
Appendix C: Biodex Balance System (Fall Risk and Postural stability) Assessment Protocol

Step by Step Protocol for Biodex Balance Testing in “Distal Radius Fracture patients between the ages of 50-80 years old”

1) Fall Risk Test

1) Press the “ON” button on the face of the Biodex to turn on the system.
2) Have patient stand on the Biodex platform and have them position their feet so they are equal distance from the vertical and horizontal line that separates the platform into 4 quadrants. Their feet should be shoulder width apart. (Fig 1&2)

Fig. 1) (Fig. 2)

3a) New Patients:
   a) Press “Testing” and select “Fall risk”
   b) Enter “Name,” “Age,” and “Height” and press “Next”
   c) Press “Start” on the face of the Biodex at this screen to have the patient practice centering the black dot in the middle of the circle.
   d) The platform will be stable during this practicing screen.
   e) Press “Record” when patient is done practicing.
   f) Press “next” (You may enter foot position if desired before Pressing next)

3b) Previously Tested
   Patients:
   - Press “Utilities” on screen.
     - Select “Patient management.”
     - Type in Password “781” and press “Ok.”
     - Use arrow keys to find patient.
     - Select the patient by pressing the “Patient name” on screen.
     - Press the “repeat” button on screen to repeat fall risk test. Be sure you have selected the right test to repeat.
     - Press “next” (May enter foot position if desired before pressing next)
4) Explain test to patient: You will perform 3 trials with each of them taking 20 seconds to complete. You will be given a 10 second break between trials. Your goal is to keep the black dot as close to the centre of the circle as possible. You will avoid using your hands to stabilize yourself unless you feel like you are going to fall. (Fig. 2)
5) Press “Start” on the Biodex face. This releases platform but does not begin test. The patient can practice for a few seconds to get used to the unstable platform.
6) Press “collect data” when ready to begin test.
7) Repeat the previous step for the next 2 trials after the 10 second rest period.
8) After the 3 trials, press “Results.”
9) Press “Print” and then “Save”
10) Press “Home” to return to the home screen

2) Postural Stability Test

1) Repeat steps 1-10 for the postural stability test. Test set up and testing procedure is the same as for the Fall Risk Test except for an added 2 steps ONLY if we are testing a new patient. (Steps g&h) See below:

3a) new patients
   g) Select “More options”
   - Change “Initial Platform Setting” to 6 and the “Ending Platform Setting” to 2. (The default setting is 8 for both initial and end platforms setting on this test)
   h) Press “ok”
Appendix D: Curriculum Vitae

Name
Sheena Philip

Post secondary Education and Degrees
Dr. M.G.R Medical university
Tamil Nadu, India
1994-1998 Bachelor of Physiotherapy (BPT)

Honours and Awards:
Western University Graduate Research Scholarship
2014 -2016

Related Work Experience
Teaching Assistant
University of Western Ontario
2014 -2015
Research Assistant
The Leprosy Mission Hospital, Allahabad, India
2000 – 2001
Conducted monofilament sensory test, manual muscle test, conduction velocity test, thermal sensory analysis, vibratory test via vibrameter on peripheral nerves affected by Hanson’s disease.

Conference Presentations
Canadian Bone and Joint Conference
April 2016
Topic: Do People with Distal Radius Fracture Differ from Normal in Terms of Postural Stability and Fall Risk.
HRS Graduate Research Conference
February 2016
Topic: Do People with Distal Radius Fracture Differ from Normal in Terms of Postural Stability and Fall Risk.

National Conference on Musculoskeletal Rehabilitation 2013
Topic: Relaxation Technique

International Conference on Mental Health Rehabilitation November 2012
Topic: Role of Physiotherapist in Mental Health Rehabilitation.

Certifications

Canadian Fall Prevention Curriculum
University of Victoria, BC
February –March 2016.

Emergency First Aid CPR Level C
March 2015

Teaching Assistant Training Program (TATP) Western University October 2014

The Western Certificate in University Teaching and Learning Western University -In progress