Falls and fear of falling in older adults who have undergone total hip and knee arthroplasty

by

Serena Kuang Yi Chen

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University of Alberta

Abstract

Falls are the leading cause of injury in community dwelling older adults over the age of 65 years. In patients with total joint arthroplasty (TJA), falls has not been studied extensively, with conflicting reports of associated falls risk factors. The overall aim of this thesis is to report the prevalence of falls in TJA patients, and to understand how fear of falling and other factors explain falls in patients with total hip or knee replacement. A scoping review was completed to broadly map existing literature on falls in TJA participants. A cross-sectional survey was conducted with participants over the age of 60 waiting for or recovering from TJA (n=198), and controls from the community (n=100). Multivariable logistic regression was used to determine factors associated with falls within TJA group and within community group. In the TJA group, 29% (n=57) reported at least one fall in the past year compared to 24% (n=24) in community controls. The mean number of risk factors for falling was significantly higher for the TJA group (6.3±3.2) as compared to community controls (3.72±2.5), $p<0.001$. Fear of falling was greater in the TJA group (ABC mean score=67.0±24.3) than the community controls (88.1±14.9) ($p<0.001$). Although TJA participants have a comparable number of falls to community dwelling older adults, they have more and different risk factors for falling and are more fearful of falling. This thesis makes a useful contribution to clinical practice by describing the prevalence of falls and factors associated with falls among people with TJA and suggesting approaches to intervention that have the potential to address falls risk. Findings from this thesis are relevant to occupational therapists and other professionals who seek to support patients before and after TJA.

Preface

This thesis is an original work by Serena Chen. The research project for this thesis received research ethics approval from the University of Alberta Research Ethics Board, Falls and fear of falling in older adults who have undergone total hip and knee arthroplasty, Project ID: Pro00065389, October 25, 2016. My thesis will extend the current knowledge on falls and fear of falling by addressing the risk factors related to falls in patients undergoing hip and knee surgery.

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List of Abbreviations

ABC	Activities-specific Balance Scale
CIHI	Canadian Institute for Health Information
FES	Falls efficacy scale
FES-I	Falls Efficacy Scale - International
FOF	Fear of falling
HMDB	Hospital Mortality Database
ICD-10	International Classification of Disease - 10
MFES	Modified Falls Efficacy Scale
OA	Osteoarthiritis
OR	Odds ratio
THA	Total hip arthroplasty
TJA	Total joint arthroplasty
TKA	Total knee arthroplasty
WOMAC	Western Ontario and McMaster Universitites Osteoarthiritis Index
VAS	Visual analogue scale

Chapter 1

1.1 Statement of the Problem

Prevalence studies report a higher risk of falls in older adults with arthritis than without arthritis, however few studies report prevalence of falls in older adults with end-stage osteoarthritis (OA) waiting for or recovering from total joint arthroplasty (TJA) (Gillespie, Gillespie, Cumming, Lamb, & Rowe, 2001). Determining the prevalence of falls in TJA patients is necessary due to the clinical seriousness of falls both to the patient and the healthcare system. Falls are the leading cause of injury in adults 75 years and older (Murray et al., 2012), and older adults whose falls result in injury have approximately a one in three chance of being discharged to a long-term care facility (Alexander, Rivara, & Wolf, 1992). The Global Burden of Disease Study of 2010 showed that falls increased in rank from the 24th to 15th leading cause of disability-adjusted life years (DALY's) from 1990 to 2010 (Murray et al., 2012). The absolute number of falls increased by 20.9% (95% CI: 14.6, 27.2) between 2005 and 2015 (Murray et al., 2012). As the population ages, the healthcare impacts and cost of falls will increase. Any fall experienced by an older adult may develop into an expensive and long-term issue due to a combination of factors such as slower reflexive movements (Stelmach, Teasdale, Di Fabio, & Phillips, 1989), frailty (Wu et al., 2013), slower recovery times from sustained injuries (Chang, Yang, & Chou, 2010), social isolation (Findlay, 2003), and presence of medical comorbidities such as OA. The direct and indirect costs of falls in Canada were estimated to be 8.68 billion dollars annually (Public Health Agency of Canada, 1998). Although several known interventions for falls exist, it is still important from clinical and health promotion perspectives to identify patient populations susceptible to specific falls risk factors. There is a need to better understand

the factors specific to TJA that influence a patient's risk for falling because of the severe consequences and high costs of falls in this patient population.

Total joint arthroplasties are elective surgical interventions to alleviate joint pain when conservative management for OA has been exhausted. In Canada from 2006 to 2010, hip and knee replacement rates increased by 13% (Canadian Institute for Health Information, 2013a). Projections estimate that costs associated with OA will increase from 2.9 billion to 7.6 billion by 2031 in Canada (Sharif et al., 2015). The prevalence of falling in patients with OA waiting for TJA ranges from 41% to 63% (Hill et al., 2016; Levinger et al., 2011; Menz, Lord, & Fitzpatrick, 2003; Tsonga et al., 2015). A cohort study of 68 participants with end-stage OA reported falls prevalence of 63% at one-year prior-surgery (Tsonga et al., 2015). Whereas a larger prospective cohort study with 282 patients with total hip arthroplasty (THA) reported a yearly falls prevalence of 41% in the year prior to surgery (Hill et al., 2016). A limitation seen in many studies is that they are small, single-center, clinical studies (Levinger et al., 2011; Matsumoto, Okuno, Nakamura, Yamamoto, & Hagino, 2012; Pozzi, Abujaber, Fenstermacher, & Zeni, 2015; Soison et al., 2014; Tsonga et al., 2015).

Current evidence surrounding how OA influences the risk of falls is conflicting due to the limited literature examining falls risk and end-stage OA patients who are eligible for TJA. Severe OA of grade 3 or 4 (Kellgren & Lawrence, 1957) is associated with several intrinsic and extrinsic risk factors including: pain, muscle weakness, balance deficits, gait deficits, self-perceived poor health, depression, and multiple medication use. Current studies suggest self-reported joint pain in women, but not men, influence falls risk more than osteoarthritis defined through radiographic imaging (Ng & Tan, 2013). Pain may be an important factor in predicting falls in patients with OA using a pain-rating scale in women 65 years and older as compared to

men (OR = 1.66; 95% CI: 1.25, 2.21) (Leveille et al., 2002). The number of falls has been reported to be higher in patients with end-stage OA after surgery as compared to the general population (Ng & Tan, 2013).

TJA patients are also more fearful of falling as compared to healthy community dwelling adults. In a longitudinal study, 62 participants before and after TJA reported significantly greater fear of falling (Activities-specific Balance Scale) as compared to healthy older adults living independently in the community ($p<0.001$) (Tsonga et al., 2016). Fear of falling is a modifiable risk factor of falls. It is an ongoing concern about falling that limits the performance of daily activities. Fear of falling is defined as a constant concern about falling, that leads to a self-imposed limitation in performance of daily activities (Tinetti, Richman, & Powell, 1990). The fear of falling may result in lower self-efficacy, which is defined as a person's perception of his or her own abilities to perform a task (Bandura, 1977). Self-efficacy is positively correlated with performance on balance tests in older adults (French, Olander, Chisholm, & Mc Sharry, 2014; Park et al., 2014) and is independently associated with balance and mobility after accounting for age, activity level, and several relevant physiological factors (Liu-Ambrose et al., 2006). An explanation of how self-efficacy impacts falls is that individuals who believe they can perform daily activities without falling are less likely to limit activity. Fear of falling has deleterious effects on mobility because activity avoidance leads to a decline in muscle mass and physical performance, which can further propagate anxiety and fear surrounding falls (Deandrea et al., 2010; Li, Fisher, Harmer, McAuley, & Wilson, 2003; Tsonga et al., 2016). Therefore, falling not only increases fear of falling but is also a physical consequence that arises from fear of falling. Among individuals over the age of 65 years who have fallen at least once in the past year, 54-77% were fearful of falling (Kim & So, 2013; Zijlstra et al., 2007). Older adults who have

experienced a fall often experience a loss in independence and confidence, which leads to a lower quality of life and premature nursing home admission (Dunn, Furner, & Miles, 1993). Other consequences of falls include: negative health effects, recurrent falls, reduced physical activity, avoidance of social activities, depression, and lower self-reported quality of life (Alexander et al., 1992; Dunn et al., 1993; Stevens, 2003).

The evidence surrounding factors related to falls and fear of falling before and after a hip or knee replacement is sparse. As the world's population ages, increasing numbers of older adults experience the physiological and psychological consequences of falls. Falls risk and how fear of falling impacts patients who are waiting or recovering from TJA is poorly understood. This research project adds to the literature because it provides an estimate of the prevalence of falls in TJA patients as compared to a community control group similar in age and sex distribution.

The overall aim of this project is to estimate the prevalence of falls in TJA patients and to understand how fear of falling and other factors explain falls in patients with total hip or knee replacement.

1.2 The Specific Objectives:

1. To systematically review the literature to identify factors that explain falls and prevalence of falls in patients who are waiting for or recovering from total joint arthroplasty
2. To report the falls and the fear of falling in TJA patients compared to community controls
3. To determine what established risk factors are associated with falls in the TJA cohort, and if these risk factors are different from those seen in the community controls.

Chapter 2: Literature Review

Falls in older adults is a serious public health concern. It is a costly and complex issue resulting in high rates of morbidity and mortality. In 2012, one in three Canadians over the age of 65 years reported falling at least once a year, this number increased with age in that one in two falls for Canadians over the age of 85 years (A. Morrison, Fan, Sen, & Weisenfluh, 2013). The number of falls in Canada is projected to increase due to the increasing senior population (Do, Chang, Kuran, & Thompson, 2015). In 2011, there were 5 million adults over the age of 65 years in Canada, accounting for 14.8% of the total population and projected to increase to 11 million (Statistics Canada, 2015a). This high proportion of older adults is due to continual below-replacement fertility levels and longer life expectancy (Statistics Canada, 2015a). Falls not only impact older adults, but also have repercussions for the senior' s families, communities, and national health care resources. The direct and indirect financial burden of falls on the Canadian economy is estimated to be 8.68 billion dollars per year (Public Health Agency of Canada, 1998).

Falls are the leading cause of injury among Canadians over the age of 65 years. They account for more injuries in older adults than transportation accidents, being struck/crushed by object, contact with sharp object/tool/machine, and overexertion/strenuous movement combined (Government of Canada, Statistics Canada, 2017). Falls also account for 85% of all older adults' injury related to hospitalization, making it the leading cause for injury related hospitalizations. Only half of older adults admitted to the hospital due to a fall will be alive one year later (Rubenstein, 2006). Fortunately, falls prevention programs such as those focused on strength, balance, flexibility, or endurance training have shown to be successful in reducing the risk of

falls (Gillespie et al., 2001). Further research on context specific risk factors for falls are needed to inform future falls prevention programs.

2.1 Definition of a Fall

What constitutes a fall differs between studies. There is no universally agreed upon definition of a fall. The three most commonly used definitions are given by: the Kellog Report (Gibson, 1987), the Canadian Institute for Health Information (Canadian Institute for Health Information, 2002; Canadian Institute for Health Information, 2013a), and the International Classification of Disease (ICD-10) (Canadian Institute for Health Information, 2002)

The Kellog Report (Gibson, 1987) defined a fall as "an event which results in a person coming to rest inadvertently on the ground or floor or other lower level and other than as a consequence of the following: sustaining a violent blow; loss of consciousness; sudden onset of paralysis, as in stroke or an epileptic seizure. The Canadian Institute for Health Information defined a fall as "an unintentional change in position where the elder ends up on the floor or ground". The ICD-10 does not provide a formal definition of a fall, however, falls is included under ICD-10 Chapter 20: External causes of morbidity and mortality. W00 to W19 describes 20 different circumstances for falls such as "fall on the same level involving ice and snow" or "fall from a ladder". Although falls have a variety of definitions, they are all similar in that a fall is unintentional and results in a person landing at a lower position. In studies that involve self-reports or surveys, the term "fall" is often left to interpretation, which could lead to under-reporting because missteps, half-falls, and non-injurious falls are often neglected. Although one fall could be the result of extenuating circumstances, two or more falls over a period of time

could represent a pattern. A "faller" is defined as someone who has fallen at least twice over the period of one year (Nevitt, Cummings, & Hudes, 1991).

2.2 Epidemiology of Falls

There are approximately five million adults over the age of 65 years in Canada, which represents 14.8% of the Canadian population (Statistics Canada, 2015a). Of these older adults, one-third of adults living in the community will fall once a year (A. Morrison, Fan, Sen, & Weisenfluh, 2013). This number increases to one in two for older adults over the age of 80 years (Cesari et al., 2002). For individuals residing in hospital settings, the falls risk range from 17% to 32% (Mion et al., 1989; Vlahov, Myers, & Al-Ibrahim, 1990). For individuals living in institutional care, the incidence rate can be as high as two in three older adults each year (Luukinen, Koski, Hiltunen, & Kivel, 1994). Falls in institutions also tend to result in more serious complications, with 10-25% of falls resulting in injuries such as fracture or lacerations (Rubenstein, 2006).

2.2.1 Non-Injurious Falls Not everyone who falls sustains an injury. The majority of falls result in minor bruises and superficial injuries (Talbot, Musiol, Witham, & Metter, 2005). These require no medical attention or are treated in a primary care setting. Hence, there is limited data on falls that do not result in hospitalization. Despite this, it is still important to discuss non-injurious falls. Even if an individual does not sustain a serious injury, experiencing a fall may still have a major impact on the individual patient. Non-injurious post-fall symptoms include fear of falling, recurrent falls, reduced physical activity, restriction of avoidance of social activities, depression, and a reduction in self-reported quality of life (Scheffer, Schuurmans, van Dijk, van

der Hooft, & de Rooij, 2008). Patients report a lower quality of life for up to nine months after a fall (Hartholt et al., 2011).

2.2.2 Injuries and Falls. Falls are the leading cause of injury in Canadian older adults 65 years and older (Public Health Agency of Canada, 2014). Fall-related injuries can lead to reduced mobility, independence, and premature admission into long-term care facilities. Fall related injury rates increase with age with individuals over the age of 90 years having the highest rate of falls (Public Health Agency of Canada, 2014). Women are also more likely to sustain an injury from a fall, which could be due to weakness and loss of bone density after menopause (Chang & Do, 2015). Trends on fall-related injuries in Canada in the previous decade have been primarily derived from three sources: 1) survey data from the Canadian Community Health Survey (CCHS), 2) hospitalization data from the Hospital Mortality Database, and 3) mortality data from the Canadian Vital Death Statistics.

Based on the CCHS from 2005, 2009/2010, and 2013, the most noticeable trends are that: self-reported fall-related injuries have increased in Canada by 54% from 49.4 per 1000 in 2005 to 58.5 per 1000 in 2013 (Chang & Do, 2015). In 2013, the CCHS found 70% of older adults over 65 years sought help at an emergency room for a fall-related injury. Most falls occurred when the respondent was walking; the most common type of injury is broken bones; and the areas of the body most commonly injured are the shoulder and upper arm (16%), the knee or lower leg (13%), and the ankle or foot (11%). One limitation of this data source is recall bias where study participants who experienced a fall, trip, or slip did not feel it was vital enough to report a fall, or did not remember their fall. The CCHS is a cross-sectional survey that asks a representative Canadian population the question, "in the past 12 months, were you injured?" Respondents who indicated "yes" were asked if that injury was the result of a fall. When

respondents answered, "yes" to both questions, additional partially closed questions were asked about the activity undertaken during the fall, the area of body injured, and the treatment of the injury.

The Hospital Morbidity Database (HMDB) (Canadian Institute for Health Information, 2013b) describes discharge data from all acute care facilities in Canada. Falls defined by ICD-10-CA are coded under W00-W19. The ICD-10 documents the place where a fall took place. The data indicates that half of all falls occur in the home. The second most common location is residential institutions at 17%. HMDB also identifies falls are the leading cause of injury-related hospitalization for older adults over 65 years. Based on data from the CIHI, the age standardized rate of fall-related hospitalizations remained constant from 13.6 per 1000 in 2007 to 13.7 in 2011. The proportion of falls-related hospitalizations compared to all injury hospitalizations for older adults over the age of 65 years also remained constant from 2006-2011 at approximately 85% (Canadian Institute for Health Information, 2013b). In 2010/2011, HMDB indicated that fall-related hospitalizations have an average length of stay of 14.4 days in older adults over 65 years and 23.5 days for fall-related injuries in older adults over 85 years (Canadian Institute for Health Information, 2013b). Many older adults may lose their independence because of a severe injury; therefore, one possible reason for this extended length of stay is prolonged waiting lists for long-term care facilities. A limitation of this data source is the absence of data on falls that were treated in clinics, or at home, which could result in an incomplete picture of all possible injury events related to a fall.

The Canadian Vital Statistics on Death provides information on direct deaths from falls where the underlying cause of death was “unintentional fall” on the death certificate for residents of Canada. Overall, the death database indicates a statistically significant increase of deaths due

to falls between 2003 and 2008 at 3.5 deaths per 10,000 in 2003 to 4.7 deaths per 10,000 in 2008 for older adults over the age of 65 years. In 2008, the age standardized mortality rates indicate higher rates of deaths for men (5.7 deaths per 10,000) as compared to women (4.1 deaths per 10,000) (Statistics Canada, 2012). Although mortality data is a good indicator for the severity of falls in older adults, it ignores unreported injuries from falls. Therefore, death data from falls only provides a small overview of the issue.

Overall, data from community surveys, hospital data, and mortality data indicate an increase in reports of falls events in the past decade. Injury rates due to falls have remained constant from 2007-2011, with unintentional falls as the main source of injury for older adults over the age of 65, indicating an increase in the number of injurious falls and burden on the healthcare system.

2.2.3 Burden of Falls. Morbidity and mortality data on falls in Canadian older adults show that 256,011 individuals or an estimated 57.5 per 1,000 population had a fall related injury in 2010 (Public Health Agency of Canada, 2014). Approximately 78,330 individuals or 16.1 per 1,000 population were hospitalized for injuries related to a fall in 2011. Deaths due to falls were 2,691 cases or 4.7 per population in 2008, and show a significantly increasing trend since 2003 (Public Health Agency of Canada, 2014). Falls are the leading cause of injury in older adults and account for 6% of all hospitalization costs for older adults over the age of 65 years. Falls also incur the highest overall direct and indirect health care costs compared with all other injuries in older adults. Direct costs of injury from falls in Canada such as hospitalization fees are estimated to be $4,457 million. Indirect costs such as loss of productivity is estimated to be $1,698 million (Public Health Agency of Canada, 1998), this number is expected to increase as the population ages. In Alberta alone, approximately 110,219 visits to the ER for a falls related

injury were reported in 2010 (Parachute, 2015). This made falls the leading cause of injury-related hospitalizations among Albertan older adults.

2.3 Fear of Falling

Fear of falling is defined as a constant concern about falling that leads to a self-imposed limitation in performance of daily activities (Tinetti et al., 1990). Fear of falling was originally described as resulting from falls or "post-fall-syndrome" (Murphy & Isaacs, 1982). Post fall syndrome was brought to attention through a study of 36 participants who had suffered a fall. The patients developed a tendency to "clutch and grab" and were "unable to walk unsupported". These traits were suggested to have developed due to the trauma of a fall; however, more recent reviews regard fear of falling as a circular relationship (Landers, 2016). Falls can induce fear of falling and having a fear of falling can lead to higher risk of falling. Fear of falling is highly prevalent in older adults, ranging from 21% to 85% of older adults across different studies (Scheffer et al., 2008). Among "fallers" or those who fall more than once during a defined period, 40-73% report a fear of falling. Of those who do not fall 50% report having a fear of falling (Jung, 2008). Early research demonstrated a strong positive correlation between falls and fear of falling (Arfken, Lach, Birge, & Miller, 1994; Tinetti, De Leon, Mendes, Doucette, & Baker, 1994). Older adults with a fear of falling have an increased risk of falls, because limitation of participation in social and physical activities, such as community activities, can lead to reductions in opportunities to build physical strength and balance (Pearson, St-Arnaud, & Geran, 2014). An increased number of falls can lead to higher rates of fear of falling (Bryant, Rintala, Hou, & Protas, 2015; Wollesen, Khler, & Mattes, 2016).

2.3.1 Measurement of Fear of Falling. Several scales have been used to measure the psychological effect of fear of falling, including the Activities-specific Balance and Confidence Scale (ABC), the Falls Efficacy Sale (FES), the Falls Efficacy Scale International (FES-I), and the Modified Falls Efficacy (MFES). The ABC measures participants' confidence in maintaining balance while engaging in more difficult activities as compared to the FES (Powell & Myers, 1995). The ABC scale is for older adults living in the community that have higher functional performance. The questionnaire is a patient-reported outcomes scale with 16 items that takes approximately 6 to 30 minutes to administer. For community dwelling older adults, the standard error of measurement, which estimates how repeated measures of a person on the same test tends to be distributed, is 1.197 (Nemmers & Miller, 2008). Normative data show an average score of 79.9 in community dwelling older adults (Huang & Wang, 2009). The ABC was found to be internally consistent ($\alpha = 0.96$) and had good test-retest reliability measured at two weeks apart ($r = 0.92$, $p < 0.001$). The ABC includes a wider range of activity difficulty as compared to the FES. The FES-I and ABC has high internal consistency (Cronbach's Alpha =0.91 and 0.92, respectively) (Morgan, Friscia, Whitney, Furman, & Sparto, 2013; Tinetti et al., 1990). The FES-I and ABC also has excellent concurrent validity (correlation coefficient: -0.84) (Scheffer et al., 2008). The FES is a 10-item questionnaire developed by Tinetti and colleagues (1990) measures simple indoor activities. The FES-I is a self-report survey that assesses the degree of self-efficacy at avoiding a fall during various physical and social activities (Yardley et al., 2005). It contains 16 items scored on a 4-point scale (1 = not at all concerned to 4 = very concerned). The scores are added up to calculate a total score that ranges from 16 to 64, with a higher score indicating a greater fear of falling. Internal consistency of the FES-I as a whole was excellent with Cronbach's alpha of 0.79 (Fitzpatrick, Davey, Buxton, & Jones, 1998). The MFES is a

modified version of the FES-I that includes four additional questions about outdoor activities (Hill, Schwarz, Kalogeropoulos, & Gibson, 1996).

2.4 Risk Factors

Due to the high incidence rate of falls in older adults and the severe consequences of a fall, prevention of falls has become a prevalent topic in public health (Elizabeth Payne, 2017). A common misconception in older adults is that falls are the result of unforeseen accidents; however, several recent systematic reviews suggest for older adults who have fallen more than once in the past year, the event is more likely due to a combination of precipitating risk factors that can be addressed or eliminated (Ambrose, Paul, & Hausdorff, 2013; Wu et al., 2013). Risk factors for falls can be separated into two main categories: intrinsic and extrinsic factors. Falls typically result from a complex interaction of several risk factors -- the higher the number of risk factors an individual is exposed to the more likely the older adult will experience a fall (Rubenstein, 2006). Below are a few of the most commonly addressed intrinsic and extrinsic risk factors.

2.4.1 Intrinsic Risk Factors. Intrinsic risk factors are factors related to a person's physical and mental health. Some risk factors are not modifiable; however it can still be crucial to identify risk factors to guide targeted interventions at those who are at high risk of falling. These factors often interact in complex ways to increase a persons' risk of falling.

Age and gender. As a person ages, they may undergo physiological changes related to physical function, sensory function, and increased number of comorbid conditions, which ultimately results in an increased risk of falling (Nevitt et al., 1991). Women are approximately

1.5 times more likely to have a fall-related injury as compared to men. Men are more likely to die from a fall with age-standardized mortality rates at 5.7 deaths per 10,000, higher than that of older women at 4.1 deaths per 10,000 (Public Health Agency of Canada, 2014; Stevens & Sogolow, 2005). There is no agreement in the literature on why women are more likely to be injured from a fall. Previous studies have implicated differences in underlying health conditions or behavioural factors (Duckham et al., 2013). For example, women have lower bone mineral density after menopause (Duckham et al., 2013; Stevens & Sogolow, 2005). A recent cross-sectional study using data from the CCHS (n=14, 881) examined risk factors specific to each gender using logistic regression and found in men 65 years and older, the strongest independent correlates of falls were: stroke (OR = 1.91, 95% CI: 1.33, 2.74) and nutritional risk (OR = 1.86, 95% CI: 1.50, 2.31). In females 65 years and older, stroke (OR = 1.53, 95% CI: 1.03, 2.27) and advanced age of 85 years or older (OR = 1.51, 95% CI: 1.14, 2.00) had the strongest association (Chang & Do, 2015).

History of falls. Previous falls is the single strongest predictor of future falls. If an older adult falls once, they are more than three times as likely to fall again (Jensen, Nyberg, Rosendahl, Gustafson, & Lundin-Olsson, 2004). History of falls is a complex risk factor as it implies the same situation of physical deterioration and/or environmental risks continues to be present and unaddressed. In addition, a previous fall can reduce mobility in the faller, resulting in loss of strength, balance, and reflex. Multi-morbidity (≥ 2 comorbid conditions) increases with age and the number of additional medical conditions may increase the risk of falls.

Comorbidities. Comorbidity is defined as the coexistence of two or more chronic conditions (Valderas, Starfield, Sibbald, Salisbury, & Roland, 2009). Having comorbidities can increase the risk of falls. Bao and colleagues (2017) found that falls risk in individuals with

comorbidities were approximately 4 times (95% CI: 3.20, 4.87) that in individuals with no comorbidities (Bao et al., 2017). Several comorbidities have been implicated as falls risk factors, including but not limited to cardiovascular disease, syncope, and musculoskeletal disorders (Rubenstein, 2006).

Dementia. Impaired cognition such as dementia can increase one's risk of falling. In a study with 2,015 nursing home residents, Van Doorn and colleagues (2003) found the risk of falls was approximately 1.7 times higher in older adults with dementia compared to older adults without dementia among nursing home residents (RR: 1.74; 95% CI: 1.34, 2.25). This may be related to impaired judgment and perception, and leading to inability to recognize and avoid hazards in the environment.

Impaired Vision. Studies indicate visual impairment can predict falls in older adults (Eriksson, 2014). In a retrospective cohort study with 298 participants, impaired visual acuity in the better eye is a risk factor for falls as compared to individuals with normal visual function (OR: 2.26; 95% CI: 1.19, 4.29). The odds of falling in those with a visual field impairment of 40% or more were 3 times that of participants with a visual field impairment less than 40% (OR: 3.0; 95% CI: 0.94, 9.8). A randomized trial with 616 participants older adults in the community showed that falls occur more frequently in the intervention group assigned to receive vision examinations and glaucoma management as compared to the control group that received usual care (OR: 1.57; 95% CI: 1.20, 2.05). This indicates comprehensive eye assessment may not reduce risk of falls (Cumming et al., 2007). One possible reason behind the disagreements in literature could be that there are risk factors that pose a greater risk for falls than visual impairment alone.

Medications. Approximately 82% (95% CI: 79.5, 85.9) of adults over the age of 65 years take at least one type of prescription medication (Statistics Canada, 2015b). This number has been steadily increasing as the population is prescribed more medications to treat chronic health issues. Studies have indicated several drugs that have a significant impact on the risk of falling. However, there is strong evidence that polypharmacy, defined, as the regular use of five or more prescription drugs, is not a significant independent predictor of falls. Instead, the use of two or more fall-risk inducing drugs (FRID) is a significant predictor for falls (OR: 2.8, 95% CI: 1.4, 5.3; p=0.001) (Zia, Kamaruzzaman, & Tan, 2017). Several drugs have been identified as fall-risk inducing drugs. Woolcott and colleagues (2009) conducted a systematic review of 22 articles analyzing the impact of 9 drug classes on falls in older adults. They concluded antidepressants (OR: 1.68; 95% CI 1.47,1.91), neuroleptics and antipsychotics (OR: 1.59; 95% CI 1.37,1.83), benzodiazepines (OR: 1.57; 95% CI 1.43,1.72), antihypertensive agents (OR: 1.24; 95% CI 1.01,1.50), sedatives and hypnotics (OR: 1.47; 95% CI 1.35,1.62), and diuretics (OR: 1.07; 95% CI 1.01,1.14) have significant associations with falls. Of the 22 articles, 14 studies were retrospective cohort or cross-sectional studies, meaning the potential for confounding by indication may be high. In older adults with chronic pain, non-steroidal anti-inflammatory drugs (NSAIDS) have been linked to a higher risk of falls. A systematic review of 12 observational studies on NSAIDS and falls risk found four of the studies showed a significantly increased OR and eight showed a non-significantly increased OR (Hegeman, van den Bemt, Bart JF, Duysens, & van Limbeek, 2009). The results of the study suggested an increased risk of falls may be probable when older adults are exposed to NSAIDs (Hegeman, van den Bemt, Bart JF, Duysens, & van Limbeek, 2009). However, more studies using a prospective

cohort design are needed to ascertain the temporal relationship between NSAIDs and falls risk in order to address confounding by indication in assessing medications and falls risk.

Fear of Falling. Fear of falling is an example of how intrinsic risk factors can increase the risk of falling in older adults. Fear of falling is the intense fear of falling and decreased participation in normal social and physical activities. In a cross-sectional study with 742 participants, 51% (n=378) reported a fear of falling (Malini, Lourenço, & Lopes, 2016). Fear of falling was associated with a history of more than one fall (OR: 2.18; 95% CI: 1.41, 3.36), use of at least seven medications (OR: 1.70; 95% CI: 1.04, 2.80) and depression (CI: 1.68, 95% CI: 1.07, 2.63). These factors may have a bi-directional relationship. For example, depressive symptoms may lead to dependence on drugs that cause dizziness and further increase the risk of falling.

Impaired mobility and gait. The most common activity undertaken during a fall is walking (Winter, Patla, Frank, & Walt, 1990). Older adults require more attention to control automatic motor functions such as walking compared to their younger counterparts (Bridenbaugh & Kressig, 2011). External distractions that divide attention between motor control required for maintaining balance and accomplishing other tasks can lead to greater gait disturbances and falls. As people age, walking speed is reduced, along with decreased stride length, and increased variability in timing of sequential steps (Menz et al., 2003). These changes decrease stability in movements, which leads to an increased risk of falling. Compared to healthy older adults who ambulate independently, those using walking aids are approximately 3 times as likely to fall (OR: 3.98; 95% CI: 1.10, 14.37) (de Mettelinge & Cambier, 2015). Use of walking aids such as canes and walkers can predict future falls risk because it can lead to impaired gait speed, step length, and swing time (de Mettelinge & Cambier, 2015).

Sedentary behaviour. Sedentary behaviour is defined as time spent in non-exercising, seated, or reclining pursuits. Several lines of evidence suggest that sedentary behaviour can lead to a long list of chronic medical conditions including reduced mobility, increased risk of chronic disease, disablement, and premature death in older adults (Katzmarzyk, Church, Craig, & Bouchard, 2009; Stamatakis, Davis, Stathi, & Hamer, 2012). Several studies took an ecologic approach to understanding the correlates of sedentary behaviour, with the assumption that there are multiple levels of influence, including individual, social, organizational/community, environmental, and policy (Owen et al., 2011). Inactivity increases the risk of falling because it leads to decreased muscle strength, balance, leg strength, and arm strength (Morris et al., 2007; Tiedemann, Shimada, Sherrington, Murray, & Lord, 2008). Treatments that include exercise reduce the risk of falls. The multi-center FICSIT (Frailty and Injuries: Cooperative Studies on Intervention Techniques) conducted RCTs to determine how exercise programs that lasted from 10 to 36 weeks affect falls. They found that increased exercises (all varying in character, intensity, frequency, and duration) resulted in 10% less falls (OR = 0.90; 95% CI: 0.81, 0.99). For exercise programs that focused on balance and gait, there was a reduction of approximately 17% less falls (OR: 0.83; 95% CI: 0.70, 0.98) (Province et al., 1995).

Risk Taking Behaviour. Behavioural risk factors include the choices older adults make with regards to taking safety measures that increases their risk of falls. Risk taking behaviors such as drinking excessive alcohol, choosing not to use recommended assistive devices such as walkers or grab bars, and inappropriate choice of clothing and footwear are all linked to falling (Kurzthaler et al., 2005). Alcohol use may lead to falls through several mechanisms, including imbalance, decreased lower extremity function, and decreased cognitive

function (Vogel-Sprott & Barrett, 1984). Chronically heavy drinkers are also linked to having a higher number of comorbidities such as stroke and hypotension, which increases falls risk (Gill et al., 1991; Rutan et al., 1992). A cross-sectional study of 5,841 older adults found that consumption of fourteen or more drinks per week was associated with a 25% increased risk of falls in older adults as compared to non-drinkers (OR:1.25; 95% CI: 1.03,1.52) (Mukamal et al., 2004).

2.4.2 Extrinsic Risk Factors. Extrinsic factors are those factors associated with the physical environment outside the individual such as the sidewalk, or the width of a step on the stairs. Fleming & Pendergast (1993) surveyed 294 people who had fallen and found that 40-60% of falls in an adult care facility can be partially attributable to hazards in the environment such as pieces of furniture, rugs, or carpets. A combination of intrinsic risk factors outlined above combined with a hazardous environment interacts to increase the risk of a fall (Rubenstein, 2006). Four main relevant extrinsic risk factors are discussed below: environmental hazards, setting, weather, and social and economic conditions.

Environmental hazards. The indoor environment can contain several hazards for falls including but not limited to: uneven flooring, slippery floors, bad lighting, and clutter. Up to 50% of Canadian older adults attribute their fall to being inside the home where hazards such as throw rugs or unbalanced furniture can result in a trip, slip or fall (Public Health Agency of Canada, 2014). Fletcher and Hirdes (2002) found that older adults with one or more tripping hazards in the home were more likely to report a fall in the past month. In a randomized control study (n=530), an occupational therapist conducted home visits and assessed the environment for hazards then suggested modification. There was 9% less falls in the intervention group as

compared to the control group who received no intervention (Cumming et al., 1999). This suggests indoor and home modifications may be an effective method for reducing falls.

Institutions. Falls are common in hospitals settings for older inpatients; with incidence ranging from of 4.1 falls per 1000 patient-days to 10 falls per 1000 patient-days (Haines et al., 2011; Renteln4Kruse & Krause, 2007). In recent years, there has been an increase in effort to address geriatric falls in hospitals, including the development of falls-risk assessment tools for patients (Fritsch & Shelton, 2017; Lpez-Soto, Manfredini, Smolensky, & Rodrguez-Borrego, 2015). A systematic review of 13 studies identified several risk factors that were found to be significant in multiple studies on in-hospital falls, including intrinsic risk factors such as: gait instability, lower limb weakness, urinary frequency or incontinence, history of previous falls, agitated confusion, and the prescription of sedatives and hypnotics (Oliver, Daly, Martin, & McMurdo, 2004). In comparison to community-dwelling older adults, older adults living in institutional care fall more often than community dwelling older adults, with approximately half of residents falling at least once, and 1.6 falls per bed per year (Vlaeyen et al., 2015).

Weather and climate. Certain weather conditions can increase the risk of falls in older adults if appropriate protective measures are not taken (Gevitz, Madera, Newbern, Lojo, & Johnson, 2017). Ice, sleet, and snow during the winter months decrease traction, which makes it more likely for older adults to lose balance. In addition, entry into buildings with smooth surfaces in wet footwear is a slipping hazard. Older adults also report a heightened sense of fear of falling during difficult weather periods and report restricting activities such as outdoor walks and social events to “play it safe”, which can compound with a sedentary lifestyle to increase the risk of future falls (Gao & Abeysekera, 2004).

Social conditions. Low-socioeconomic status individuals are at a higher risk for falls. This could be due to several reasons such as neighbourhood factors. Nascimento and colleagues (2016) found that neighbourhoods with moderate homicide rates were associated with higher rates of falling as compared to neighbourhoods with low homicide rates (Prevalence Ratio:1.57; 95% CI:1.06, 2.31). Similarity, a qualitative study done in fourteen adults over the age of 65 years from 3 urban senior centers found that (1) built outdoor environment contributes to perceived falls risk and fear of falling and (2) outdoor neighbourhood features are a motivator for active living, which can decrease falls risk (Chippendale & Boltz, 2015).

Falls don't always happen by accident, and ageing does not lead to unavoidable falls. Often, one or more risk factors contribute to the fall. Therefore, identification of the risk factors that puts individuals at a higher risk of falls should be identified. Table 2-1 summarizes the risk factors discussed in this review of the literature.

Table 2-1 Intrinsic and extrinsic risk factors for falls in older adults

Intrinsic Factors	Extrinsic Factors
• Age and Gender • History of Falls • Comorbidities • Dementia • Impaired Vision • Medications • Fear of Falling	• Environmental Hazards • Setting • Weather and Climate • Social Conditions

• Impaired Mobility and Gait • Sedentary Behaviour • Risk Taking Behaviour	

2.5 Falls Prevention

With the rate of fall-related injuries increasing over time, there has also been an increase in falls prevention research on effectiveness of falls prevention interventional strategies (Sherrington et al., 2016). Prevention efforts require collaboration among different organization and health sectors in the community including physicians, care facilities, and researchers. Prevention for falls can be at two levels: primary and secondary.

2.5.1 Primary Prevention. Primary prevention efforts involve interventions that are applied to the community to decrease falls overall. These interventions include proper building standards for sidewalks/steps and educating older people on risks of falling and how to avoid falls. Primary intervention, if effective, has the potential to be the least costly while influencing the most amounts of people. Early detection of at risk individuals is considered primary prevention. Various fall risk assessment tools have been developed in the past two decades to evaluate fall risks and to determine `high risk' individuals. Assessments such as the Berg Balance test (Berg, Wood-Dauphinee, Williams, & Maki, 1992) the Timed Up and Go test (TUG) (Podsiadlo & Richardson, 1991) and the sit to stand test (Bohannon, 1995) have been used as primary outcomes to evaluate intervention for falls. The Timed Up and Go test has some ability to predict falls in community dwelling adults. In a recent systematic review of 10 studies, the TUG was more effective at ruling in rather than ruling out falls in high-risk individuals (>13.5 seconds) (Barry, Galvin, Keogh, Horgan, & Fahey, 2014). In another systematic review of falls risk assessments, the Berg Balance Scale (BBS) and the TUG showed good discriminant validity (Kim & Xiong, 2017). As people age, they become more vulnerable to falls, which is where secondary intervention takes place.

2.5.2 Secondary Prevention. Secondary intervention targeted at individuals with a past history of falls, and has been shown to be an effective form of intervention (Stevens, 2005). It identifies older adults over the age of 70 who had falls in the past as a high-risk group and provides targeted, personalized interventions. There is agreement in the literature that the most efficient falls-prevention strategies begin with a risk assessment of falls at the individual level (Stevens, 2005). A systematic review of the literature on risk assessment tools indicated that simple risk assessments that addresses risk factors that are easily modifiable such as medications, confusion, and history of falls could predict falls with sensitivity of up to 70% (Oliver et al., 2004). Since each individual has his or her own unique living conditions, physical conditions, and behaviours, risk management needs to be tailored to the individual in order to moderate as many risk factors as possible. Currently there are no falls prevention programs directly targeting TJA patients across Canada. However, a recent study determined the Hendrich Fall Risk Score could accurately identify patients at an increased risk for readmission following a joint arthroplasty in Medicare patients (Ravi, Nan, Schwartz, & Clarke, 2017).

Exercise programs. Physical activities such as exercise, mobility training, gait training, muscle strengthening, and balance training have been shown to be effective at reducing fall risk. A systematic review of 54 RCT's using Cochrane guidelines for exercise based interventions for falls concluded that multicomponent programs which include balance training in combination with other exercise components such as walking or more exercise are the most effective at reducing falls (Tiedemann et al., 2008). An systematic review with 88 randomized control trials found that exercise alone reduced falls in community dwelling older adults (rate ratio: 0.79; 95% CI: 0.73, 0.85, $p<0.001$, I^2 47%, 69 comparisons). Exercises that included challenging balance training (IRR: 0.79; 95% CI: 0.71, 0.88) and exercises that include more than 3 hours per week

of training (IRR: 0.70; 95% CI: 0.60, 0.83) have greater falls prevention effects that interventions without balance training or more than three hours of training. Brisk walking is one intervention that may increase the risk of falls (Sherrington et al., 2016). Tai Chi, a form of low intensity exercise that involves conscious awareness of body positions and slow movements has been shown to improve balance control and proprioception (Huang, Feng, Li, & Lv, 2017), and is beneficial for falls reduction (Plummer & Bradley, 2017).

Medication Reviews. It is recommended that older adults have their medications reviewed annually for possible interaction effects between medications (Phelan, Mahoney, Voit, & Stevens, 2015). The Beers criteria lists potentially inappropriate medications for older adults at risk for falls to improve the safety of prescribing multiple medications (Berryman et al., 2012). Some medications are more prone to increasing the risk of falls such as psychotropic drugs that improve mood. As understanding of these medications and falls awareness increases, removal of certain medications from routine can be done safely to reduce fall risks.

2.6 Osteoarthritis and Falls

The Global Burden of Disease Study shows musculoskeletal diseases to be the second greatest cause of disability on the global front (Horton, 2012). In particular, the greatest increase of disability over the last 20 years was associated with OA (Horton, 2012). Osteoarthritis has been recognized for decades as a leading cause of mobility related disability in older adults (Guccione et al., 1994; Oliveria, Felson, Reed, Cirillo, & Walker, 1995). Osteoarthritis is a reported as a risk factor for falls in older adults with a reported odds ratio of 1.6 (95% CI: 1.14, 2.24) (Doré et al., 2015)

Osteoarthritis is prevalent disease with a prevalence of 44.6% in older adults aged 60 and over (Government of Canada, Statistics Canada, 2014). In 2006, 8.5 million physician visits in Canada were for arthritis (O'Donnell, Lagacé, McRae, & Bancej, 2011). The knees, hip, hand, spine, and foot are most commonly affected by OA. Prevalence of osteoarthritis increases with age, making it difficult to discern whether fall events are age-related or the result of the osteoarthritis and associated symptoms such as pain (Lawrence et al., 2008). In individuals with osteoarthritis stiffness of joints and pain during walking can increase the fear of falling and the risk of falls.

When conservative measures for OA of the hip and knee have been exhausted, total hip arthroplasty (THA) and total knee arthroplasty (TKA) are elective surgical option for pain relief and functional improvement. From 2012 to 2016, more than 400,000 primary hip and knee replacements were performed in Canada, resulting in 78, 330 hospitalizations (Canadian Institute for Health Information, 2015). Although TJA reduces pain and improves gait performance and balance, individuals may still show poorer performance on the 10-m walking test, timed up and go test, and sit-to-stand tests after surgery as compared to healthy community dwelling controls, all of which are factors strongly associated with increased risk of falls and fear of falling (Schache, McClelland, & Webster, 2014).

2.7 Methodological Considerations of Measurement of Falls

2.7.2 Lack of Uniformity in Definitions of Falls. A systematic review of 90 papers that measured falls as an outcome indicated a lack of uniformity in the definition of falls (Hauer, Lamb, Jorstad, Todd, & Becker, 2006). Of the 90 papers, 44 did not provide a definition of a fall. In addition, the most frequently used falls definition of "an unexpected event in which the participant comes to rest on the ground, floor, or lower level" (Tinetti, Speechley, & Ginter,

1988) were edited or slightly adjusted. The most common adjustment is whether the fall was attributable to medical events such as syncope and seizures. Other adjustments were whether the fall resulted in bodily contact with the ground or floor, and whether the fall was due to overwhelming external force (Hauer, Lamb, Jorstad, Todd, & Becker, 2006). Differing definitions of falls may lead to misclassification of falls events. Underestimation of falls events may occur, especially if falls events did not result in injuries (Ziere et al., 2006). This can make comparisons of results between studies difficult, even at the systematic review level.

2.7.1 Sources Used to Report Falls. Sources used to identify falls can be separated into four main categories: prospective methods, retrospective methods, database records, and electronic devices. Prospective methods include the use of a calendar, a patient diary, or a post-card to ascertain fall events. A commonly cited recommendation in the literature currently is prospective recording over a long period of time for sufficient events to occur (Chaudhuri, Thompson, & Demiris, 2014). Retrospective recall methods include face-to-face interviews, questionnaires, or telephone calls.

Both of these methods use varying recall times, which could result in substantial increases or decreases in number of reported falls. In a 1-year prospective study, patients recalled falls and fall related injuries in the previous 12 months well, but were less accurate for recall periods of 3 and 6 months (Hale, Delaney, & Cable, 1993). Fujimoto and colleagues (2000) in a study of 350 individuals found male participants reported significantly more falls per year when asked about incidence of falls at a frequency of once per month at 20.5% (n= 116), than when asked about falls once every three months at 16% (n=116), and asked once about falls at the end of the year at 6.4% (n=118). Considering the participants of the study was similar in age, sex,

walking ability, and history of hospitalization, the study shows that falls ascertainment methods play a significant role in prevalence reports of falls. Participants who suffered an injury from a fall may be more likely to recall a fall. In addition, individuals who did not suffer a consequence from a fall may have difficulty recalling the number of times they fell in the past year, leading to an under-reporting of falls prevalence.

Database records include the use of hospital or emergency room records, however, hospitalization data has been shown to under-report fall-events of participants (Haga et al., 1996). Technology measuring falls include wearable systems like an accelerometer (Chaudhuri et al., 2014). Several studies have used body sensor technology to measure falls (Bourke, O'brien, & Lyons, 2007; Kangas et al., 2009; Nyan, Tay, & Murugasu, 2008) with some studies suggesting an electronic device worn at the waist may be optimal for fall detection (Kangas, Konttila, Lindgren, Winblad, & Jms, 2008). Body sensor technology addresses the issue of recall bias, which prevents under-reporting of falls prevalence.

2.7.3 Recall Bias. Systematic errors may result from studies that require recalling a past event. Participants who suffered an injury from a fall are more fearful of falling may be more likely to recall a fall as opposed to the comparison group, which are commonly community dwelling older adults. In addition, individuals who did not suffer a consequence from a fall may have difficulty recalling the number of times they fell in the past year, leading to an under-reporting of falls prevalence.

2.8 Conclusion

Falls are a major public health concern as the demographics shift to an older population. Fall-related injuries have large societal and individual consequences and will continue to be a growing problem. Identifying risk factors is the first step to reduce fall susceptibility. A fall is typically the result of additive effects of several risk factors separated into: biological, behavioural, environmental, and socio-economic conditions. The literature strongly supports the idea of personalized interventions and addressing multiple risk factors in older adults to decrease the risk of falling (Vlaeyen et al., 2015) starting with at risk populations such as those with end-stage OA most of whom have multiple risk factors for falls such as high number of comorbid conditions, pain, and fear of falling.

Individuals with OA waiting for a TJA may be at risk for fallings. Fall rates have remained stable in Canada over the past ten years despite an ageing population. As the population grows, there will be more falls, which is a burden at the societal level. Clinically, patients recovering from TJA are at a high risk for falls; however, little work has specifically looked at the prevalence of falls in this population and the risk factors that predispose this population to falls.

Falls and Fear of Falling in Total Joint Arthroplasty Patients: A Scoping Review

Authors

Serena Kuangyi Chen BSc, University of Alberta, Edmonton Alberta, T6G 2G4, serenaku@ualberta.ca

Don Voaklander, PhD, School of Public Health, University of Alberta, Edmonton, Alberta, T6G 2G4 dvoaklander@ualberta.ca

C. Allyson Jones, PhD, Dept Physical Therapy, University of Alberta, Edmonton, Alberta T6G 2G4 cajones@ualberta.ca

3.1 Abstract

Background: Significant improvements are seen with function after total joint arthroplasty (TJA), yet patients may be at a higher risk of falls due to having several risk factors such as fear of falling, older age, and pain. The objective of this scoping review is to examine prevalence of falls, fear of falling, and factors associated with falls in TJA patients.

Methods: The scoping review was completed based on electronic search in Pubmed, Medline, CENTRAL, Embase, CINAHL Plus with Full Text, Web of Science, and SCOPUS from 1946 to April 6th, 2017. A combination of key search terms were used to identify papers on falls prevalence, fear of falling, and factors related to falls in TJA patients.

Results: Inclusion criteria of studies included were of a) participants waiting for TJA or has already had a TJA due to osteoarthritis and b) measured falls c) English only articles, and d) observational studies such as retrospective cohort, prospective cohort, case-controls, and cross-sectional studies. Twelve articles fit the inclusion criteria, including 5 cross-sectional studies, 5 prospective cohort studies, and 2 retrospective cohort studies. Prevalence of falls in pre-operative TJA patients ranged from 22.5% (n=31) to 63% (n=43), and 11.1% (n=99) to 36% (n=214) in post-operative patients. Fear of falling was highest in pre-operative TJA patients.

Keywords: Total Joint Arthroplasty, Falls, Fear of Falling, Older Adults, Osteoarthritis, Scoping

3.2 Background

Falling is a major public health problem for older adults and the leading cause of injury in community dwelling older adults (Carroll, Slattum, & Cox, 2005). Falls are the l1th leading cause of years lived with disability globally (Vos et al., 2012) and among the 20 most costly injuries. In 2009, the total financial burden of falls was 8.85 billion and led to 78,330 annual hospitalizations in Canada (Public Health Agency of Canada, 1998). Osteoarthritis (OA), a disease defined by symptoms of joint pain and changes in bone structure and cartilage, is a prevalent condition in older adults. In 2009, Statistics Canada reported 44.6% of Canadians were diagnosed with OA (Canadian Institute for Health Information, 2015). When conservative management fails to relieve pain caused by OA, total hip arthroplasty (THA) or knee arthroplasty (TKA) are elective surgeries that provide significant pain relief and physical functional improvement.

Osteoarthritis is associated with increased falls risk (OR: 2.4; 95% CI: 1.6, 5.4) (Scott, Wagar & Elliott, 2011). Intrinsic risk factors which are associated with falls in community dwelling older adults and are characteristic of OA include muscle weakness (RR:4.9; 95% CI: 1.9, 10.3), balance deficits (RR:3.2; 95% CI: 1.6, 5.4), and gait deficits (RR:3.0; 95% CI: 1.7, 4.8) (Rubenstein, 2006). Other risk factors of falling that are commonly seen with ageing are poor vision (Lord, Smith, & Menant, 2010) cognitive impairments (Axer, Axer, Sauer, Witte, & Hagemann, 2010; Sheridan & Hausdorff, 2007) and chronic illnesses (Ashburn, Stack, Pickering, & Ward, 2001; Sheridan & Hausdorff, 2007). Patients with OA who are waiting for total joint replacement may be at a higher risk for falls compared to community dwelling adults without OA due to the presence of several additional risk factors such as pain (OR: 1.36, 95% CI: 1.02, 1.82), self-perceived poor health (OR:1.50, 95% CI: 1.15, 1.96), depression (OR:1.63, 95% CI:

1.36, 1.94), multiple medication use (OR:1.06, 95% CI: 1.04, 1.08), and fear of falling (OR: 1.55, 95% CI: 1.14, 2.09) (Deandrea et al., 2010; Kwan, Lin, Chen, Close, & Lord, 2011; Leveille et al., 2002).

Fear of falling, a constant concern about falling that leads to a self-imposed limitation in performance of daily activities, can develop as a result of falls, but is also an independent predictor of falls regardless of a person's fall history (Chu, Chi, & Chiu, 2005; Tinetti et al., 1990). Fear of falling increases with age and is present in up to 56% of healthy community dwelling older adults (mean age: 71.6 ± 6.1 years) (Fucahori, Lopes, Correia, Silva, & Trelha, 2014; Scheffer et al., 2008). A longitudinal study of 35 participants reported significantly more fear of falling before and after total joint arthroplasty (TJA) as compared to 27 healthy older adults living independently in the community ($p<0.05$) (Levinger et al., 2011). A high level of fear of falling after surgery can reduce self-efficacy, or one's perception of their ability. A recent systematic review of 15 articles reported a high fear of falling is associated with less time spent on exercise, loss of mobility, and an increase in falls following a THA (Visschedijk, Achterberg, Van Balen, & Hertogh, 2010).

To our knowledge, no systematic or scoping reviews examining the prevalence of falls, fear of falling, and the factors associated with falls in a TJA patient population. This older group has a number of intrinsic risk factors that puts them at risk for falling. Summarizing current evidence of falls and fear of falling in TJA patients is needed due to the high costs and consequences of falls in this population (Asche et al., 1996; Felson & Zhang, 1998; March & Bagga, 2004). The objective of this scoping review is to identify existing evidence regarding prevalence of falls and the factors associated with falls in older adults who are waiting for or recovering from total joint arthroplasty.

3.3 Methods

A scoping review identified the prevalence of falls, fear of falling, and factors related to falls before and after total joint arthroplasty. Inclusion criteria were a) participants waiting for either THA or TKA or has already had a TJA due to osteoarthritis and b) measured falls c) English only articles, and d) observational studies such as retrospective cohort, prospective cohort, case-controls, and cross-sectional studies. Exclusion criteria were a) case studies and b) conference reports. Ethics approval was obtained through the University of Alberta Health Research Ethics Board (PRO 00065389).

The primary outcomes of interest were a) number of fallers in TJA participants, where only direct reports of falls were of interest which excluded indirect balance measures b) fear of falling in patients waiting for or recovering from surgery. Secondary outcomes of interest were a) risk factors that found to be significantly associated with falls.

The search strategy was developed and implemented with the assistance of a health sciences librarian with no date restrictions. Seven electronic databases were searched from 1946 to April 6, 2017: Pubmed, Medline, CENTRAL, Embase, CINAHL Plus with Full Text, Web of Science, and SCOPUS. Research in-progress was searched via abstracts from Pubmed's epub. Non-English studies were included in the literature search then excluded at the time of abstract review. The search strategy included the following keyword terms and concepts: 1) arthroplasty 2) knee joint or hip joint 3) osteoarthritis 4) accidental falls (see Appendix B).

Those articles that met the inclusion criteria were imported into RefWorks where exact duplicates were removed electronically. The remaining studies were imported into COVIDENCE

where two reviewers (Serena Chen & Danielle Perry) independently screened all abstracts for title and abstract applicability and inclusion criteria. If either author selected an article, both authors completed a full-text review. Full-text articles were reviewed based on the detailed inclusion criteria and there was "moderate" inter-rater reliability agreement (Kappa =0.69) (McHugh, 2012). Both parties resolved all disagreements and came to a consensus, resulting in the studies included in the final analysis. Data for the full articles were extracted by one reviewer (SC).

3.3.1 Quality Assessment

One reviewer (SC) used the SIGN Guidelines Checklist 3: Cohort Studies (Scottish Intercollegiate Guidelines Network, 2014) to assess individual study quality through completion of a cohort/cross-sectional checklist. The checklist included 14 questions that addressed four areas: (1) selection of subjects (2) assessment of outcome, (3) confounding, and (4) statistical analysis. Studies were given either a "high", "acceptable", or "low" rating. Because of the methodological and clinical heterogeneity of the included studies, meta-analyses could not be conducted.

3.4 Results:

The electronic search (see Appendix B) yielded a total of 866 references with the search parameters: 293 in EMBASE, 240 in SCOPUS, 174 in MEDLINE, 82 in Web of Science, 45 in CINAHL, 25 in CENTRAL, five in PubMed (of pub ahead of print only). Among them 335 were duplicates. There were no non-English articles. 531 articles were screened at the title level, and 127 were removed. The remaining 404 articles were screened at the abstract level by two reviewers (SC and DP). A total of 12 studies were included for full-text review (Hill et al., 2016;

Ikutomo, Nagai, Nakagawa, & Masuhara, 2015; Levinger et al., 2011; Matsumoto, Okuno, Nakamura, Yamamoto, & Hagino, 2012; Mitchell et al., 2007; Pozzi, Abujaber, Fenstermacher, & Zeni, 2015; Riddle & Golladay, 2016; Smith, Pearson, & Latham, 2016; Soison et al., 2014; Swinkels, Newman, & Allain, 2008; Tsonga et al., 2015; Tsonga et al., 2016).

All twelve studies were included regardless of methodological quality (Table 3-1). Five studies were cross-sectional studies, five were prospective cohort studies, and two were retrospective cohort studies.

Based on SIGN guidelines, of the twelve studies, four were poor quality (Ikutomo, Nagai, Nakagawa, & Masuhara, 2015; Mitchell et al., 2007; Pozzi et al., 2015; Soison et al, 2014) six were acceptable quality (Hill et al., 2016; Levinger et al., 2011; Riddle & Golladay, 2016; Smith, Pearson, & Latham, 2016; Tsonga et al., 2015; Tsonga et al., 2016) and two were high quality (Matsumoto et al., 2012; Swinkels, Newman, & Allain, 2008). Assignment of poor quality was due to several factors including missing confidence interval estimates (n=1) and failure to discuss presence of potential bias (n=2).

3.4.3. Sample Size and Population

Studies occurred in several countries with three studies conducted in the UK (Mitchell et al., 2007; Riddle et al., 2016; Smith et al., 2016), 2 in Japan (Ikutomo et al., 2015; Matsumoto et al., 2012), two in Australia (Hill et al., 2016; Levinger et al., 2011), two in USA (Pozzi et al., 2015; Riddle & Golladay, 2016), two in Greece, which used the same cohort (Tsonga et al., 2015; Tsonga et al., 2016) and one in Thailand (Soison et al., 2014).

Most studies were small in size and single-center (Pozzi et al., 2015; Soison et al., 2014; Tsonga et al., 2015; Tsonga et al., 2016). Sample sizes ranged from 31 to 413 participants (Table

3-1). The five smallest samples were set in a single clinic with sample sizes of 31 (Pozzi et al., 2015), 54 (Soison et al., 2014), 74 (Matsumoto et al., 2012), and 68 (Tsonga et al., 2015; Tsonga et al., 2016), a sample that produced two papers. The three largest samples (>282) were multi-center (Hill et al., 2016; Smith et al., 2016). Two studies with cases: 413 (Riddle & Golladay, 2016) and 269 (Smith et al., 2016) used data from the Osteoarthritis Initiative (OAI) database, a study that followed OA patients for seven years at five different recruitment centers.

Average ages of participants ranged from 63.9 (Tsonga et al., 2016) to 75.0 (Matsumoto et al., 2012) years. Most studies had a majority of females, accounting for 85% (n=46) to 100% (n=31) of the samples (Ikutomo et al., 2015; Matsumoto et al., 2012; Pozzi et al., 2015; Tsonga et al., 2016).

3.4.4. Defining Falls

The six studies that formally defined falls used the definition: “an unexpected event in which the participant comes to rest on the ground, floor, or lower level, not as a result of a major intrinsic event such as a faint or stroke, seizure, or an overwhelming external hazard" (Ikutomo et al., 2015; Matsumoto et al., 2012; Soison et al., 2014; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016). However, half of the studies did not explicitly define what constituted a fall in their study population (Hill et al., 2016; Levinger et al., 2011; Mitchell et al., 2007; Pozzi et al., 2015; Riddle & Golladay, 2016; Smith et al., 2016), allowing participants to use their own interpretation of questions such as “how many times have you fallen in the past 12 months?” Eight studies (Hill et al., 2016; Mitchell et al., 2007; Pozzi et al., 2015; Riddle & Golladay, 2016; Soison et al., 2014; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016) compared self-reported “fallers” to “non-fallers”.

3.4.5. Falls Prevalence

Time frames for pre-operational and post-operational patients are specified in Table 3-1. Five studies examined falls prevalence in pre-operative only patients (Hill et al., 2016; Levinger et al., 2011; Mitchell et al., 2007; Pozzi et al., 2015; Tsonga et al., 2015), four studies examined post-operative only patients (Ikutomo et al., 2015; Matsumoto et al., 2012; Smith et al., 2016; Soison et al., 2014), and three studies compared falls rates before and after surgery (Riddle & Golladay, 2016; Swinkels et al., 2008; Tsonga et al., 2016). Falls prevalence in pre-operative patients was higher than post-operative patients. Specifically, pre-operative participants were asked two to four weeks before surgery and reported prevalence rates of falls over one year to be 63.2% (Tsonga et al., 2015), 48% (Levinger et al., 2011), and 41% (Hill et al., 2016). Thirty nine percent of pre-operative participants on a waitlist for surgery reported having at least one fall in the previous month (Mitchell et al., 2007). The lowest pre-operative prevalence in this review was 22.4% over six months (Pozzi et al., 2015), measured at two weeks before surgery, and may be due to the small sample size (n=31). Yearly post-operative prevalence rates were lower than pre-operative prevalence at 26% (n=269), 36% (n=214), and 32% (n=74) measured one to four years post-surgery. The highest yearly post-operative prevalence reported was 42% (n=54); however, participants were interviewed at greatly varying times after surgery, ranging from 7 months up to 6 years after initial surgery (Soison et al., 2014).

Longitudinal studies of TJA participants in the same cohort supported the trend of higher fall rates seen pre-operatively as compared to post-operatively. In a one year follow up study, pre-operative participants reported falls prevalence of three months to be 24.2%, twice as high as the prevalence of 12%, 11%, and 11% in the same patients at 3, 6, and 12 months post-

operatively (Swinkels et al., 2008). In another prospective cohort study, Tsonga followed 68 patients over one year and found 62.3% of pre-operative patients reported at least one fall in the year leading up to surgery, and only 22.1% of post-operative individuals had a fall in the year following surgery, assessed through monthly telephone follow up call that asked "did you have a fall this past month?" (Tsonga et al., 2016). However, the largest study with 413 cases of TKA patients followed patients for eight years found no significant changes in the number of falls during the perioperative period with yearly self-reported falls of 15-23% for women and 8-13% for men (Riddle & Golladay, 2016).

3.4.6. Fear of Falling

Of the twelve studies reviewed, five studies (Hill et al., 2016; Levinger et al., 2011; Matsumoto et al., 2012; Swinkels et al., 2008; Tsonga et al., 2016) measured fear of falling using several different instruments. The Falls Efficacy Scale (FES) (Hill et al., 2016), the Falls Efficacy Scale International (FES-I) (Levinger et al., 2011), the Modified Falls Efficacy Scale (MFES) (Matsumoto et al., 2012), and Activities-Specific Balance and Confidence scale (ABC) (Hill et al., 2016; Swinkels et al., 2008; Tsonga et al., 2016).

Total joint arthroplasty patients are more fearful of falling than community dwelling older adults. Both pre-operative (FES-I=11.4± 3.0) and post-operative (FES-I=9.7±2.9) patients are significantly ($p<0.05$) more concerned about falling than community dwelling seniors (FES-I=7.6±1.2) (Levinger et al., 2011). Within the TJA group, those who are waiting for surgery (pre-operative patients) are more fearful than those who have had surgery (post-operative patients) (Levinger et al., 2011; Swinkels et al., 2008; Tsonga et al., 2016). Studies that measured fear of falling using the Activities-Specific Balance and Confidence (Swinkels et al., 2008; Tsonga et

al., 2016) found that pre-operative patients reported 61.7% (Swinkels et al., 2008), and 63.7% (Tsonga et al., 2016) confidence in ability to do daily tasks without falling, which was significantly lower than post-operative patients at twelve months after surgery at 72.8 ± 25.6% (Swinkels et al., 2008), and 81.4±16.2% (Tsonga et al., 2016) (p-value not reported and $p<0.001$, respectively). The same conclusions were drawn using the FES-I (Levinger et al., 2011), where pre-operative TKA patients were more concerned (FES-I=11.4± 3.0) than post-operative patients (FES-I=9.7±2.9) about falling ($p<0.05$). Tsonga and colleagues (2016) asked pre-operative TKA participants directly, "are you afraid of falling?" and 82.4% (n=54) indicated yes while only 44.1% (n=30) of one-year post-operative participants responded "yes". Being fearful of falling at one-year post-operative is a significant predictor of falls (OR: 11.90, 95% CI: 2.20, 64.20) when adjusting for age (Tsonga et al., 2016).

Fallers are more fearful of falling than those without a history of falls. In a study of pre-operative patients (Hill et al., 2016), those who reported a fall had less confidence (ABC=63.8 ± 20.6, FES-I=13.5 ± 5.6) to perform daily tasks as compared to non-fallers (ABC=71.2 ± 22.1, FES-I=11.4 ±3.8) ($p=0.01$), the same trend is found again in post-operative patients where fallers (ABC=79±14) had less confidence than non-fallers (ABC=82±16.9) at 6 months after surgery. Contrary to above findings, a prospective cohort study (n=74) found no significant differences in Fear of falling between TKA fallers (MFES=122 ± 27.1) and non-fallers (123.3 ± 23.3) (Matsumoto et al., 2012).

3.4.7. Risk Factors Associated with Falls

Type of Total Joint Arthroplasty (TKA/THA). Seven studies examined TKA patients (Levinger et al., 2011; Matsumoto et al., 2012; Riddle & Golladay, 2016; Soison et al., 2014;

Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016), as compared to two articles that examined THA patients (Ikutomo et al., 2015; Pozzi et al., 2015). Three studies examined TJA combining both THA and TKA (Hill et al., 2016; Mitchell et al., 2007; Smith et al., 2016); and two papers compared THA and TKA patients separately (Hill et al., 2016; Smith et al., 2016). Patients with TKA have more reported risk factors for falls in comparison to patients with THA. Hill and colleagues (2016) reported 5 factors associated with falls in TKA patients which were FES-I scores, ABC scores, WOMAC function, self-perceived quality of life (SF-36 mental), and pain catastrophizing scale. Only one risk factor was associated with falls in THA patients which was falls efficacy (FES-I and Activities-specific Balance Confidence Scale) (Hill et al., 2016). Smith and colleagues (2016) found that falls in THA patients were associated with a previous TKA surgery and presence of OA, however this association could be due to age, since THA participants were older (mean age: 71.1, SD: 9.2) than TKA participants (mean age: 67.6, SD: 9.1) (Smith et al., 2016). Overall, evidence suggests TKA patients may have more risk factors for falls as compared to THA patients.

WOMAC. Of the twelve reviewed articles, seven articles measured Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores (Hill et al., 2016; Levinger et al., 2011; Mitchell et al., 2007; Soison et al., 2014; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016) including: WOMAC pain, WOMAC function, and WOMAC stiffness. The scales used for WOMAC were either VAS Scale (range: 0-2400, 0=best) or Likert scale (range: 0-96, 96=best): Most studies (Hill et al., 2016; Mitchell et al., 2007; Soison et al., 2014; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016) did not find significant differences with regards to WOMAC measures when comparing fallers and non-fallers. Two of the three studies that reported significant differences in WOMAC subscales: pain, stiffness, and

function between those who reported and fall and those without falls had quality ratings of "poor", and the association may be due to confounders such as age (Mitchell et al., 2007; Soison et al., 2014).

Articles measuring the association between WOMAC subscales: function, pain, and stiffness and falls had mixed conclusions depending on the subscale. However most "high" quality to "acceptable" quality studies reported not statistically significant differences in at least one WOMAC subscale score (Hill et al., 2016; Soison et al., 2014; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016). Only one cross sectional study reported differences in WOMAC stiffness using multiple linear regression (coefficient: -0.141, SE: 0.0049, $p<0.05$), and WOMAC pain (coefficient= 0.048, $p<0.05$) in patients who reported a history of falling and those without falls (Soison et al., 2014). This may be due to the timeframe between TKA and the survey interview date, ranging from seven months after TKA to 73 months after TKA (mean time post TKA 38.9, SD: 16.6 months). Studies that did not report differences for WOMAC subscales measured falls at 1-12 months post TJA (Hill et al., 2016; Mitchell et al., 2007; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016).

Joint range of motion. Two studies (Matsumoto et al., 2012; Pozzi et al., 2015) examined the relationship between THA (Pozzi et al., 2015) or TKA (Matsumoto et al., 2012) arthroplasty range of motion and falls risk. For THA patients (n=31), total hip range of motion (degrees) and knee extension on surgical and non-surgical side (Nm/kg) was significantly different between fallers and non-fallers (Table 3-1), with non-fallers having more favourable outcomes. In TKA patients, Matsumoto and colleagues (2012) conducted a multivariable analysis (n=74) and determined restricted range of knee flexion, categorized into 10-degree groups ranging from 80-140 (OR: 0.28, 95% CI 0.09, 0.87; $p = 0.028$) and ankle plantar flexion categorized into 10-

degree groups ranging from 60-135 (OR 0.59, 95% CI 0.37, 0.95; p =0.028) at 12 months after surgery were significant risk factors for falls, meaning a 10-degree increased significantly reduced the odds of a fall.

Quality of Life. Four of twelve reviewed studies measured quality of life through the Short Form Health Survey (SF-36) (Hill et al., 2016; Mitchell et al., 2007; Tsonga et al., 2015; Tsonga et al., 2016). Most studies did not find significant differences between one-time fallers and non-fallers in ratings of SF-36 mental component (Mitchell et al., 2007; Tsonga et al., 2015; Tsonga et al., 2016). However, one cross-sectional study with 197 TKA patients and 85 THA patients found a significant difference between non-fallers (SF-36 Mental: 54.9 ± 9.7) and multiple (2+) fallers (SF-36 Mental 50.6 ± 13.1) (p=0.03) in TKA patients only (Hill et al., 2016), indicating multiple fallers in TKA patients may be considered a different subset of at-risk patients as compared to single or non-fallers. Remaining studies with an "acceptable" rating in quality concluded no significant differences in SF-36 physical role and SF-36 physical function dimensions and falls (Hill et al., 2016; Tsonga et al., 2015; Tsonga et al., 2016).

Depression. Five studies examined the association between falls and depression. Two studies examined THA patients with 84 (Mitchell et al., 2007) and 85 (Hill et al., 2016) patients. Five studies examined TKA participants with 54 (Soison et al., 2014), 115 (Mitchell et al., 2007), 118 (Swinkels et al., 2008), 197 (Hill et al., 2016), and 413 (Riddle & Golladay, 2016) patients. Overall, weak to moderate evidence supports the association between falls and higher depression scores. Depression was identified by the Cardiac Depression Scale (Hill et al., 2016), the Geriatric Depression Scale (GDS) (Matsumoto et al., 2012; Swinkels et al., 2008) and depression through self-report (Mitchell et al., 2007). Most studies (Hill et al., 2016; Mitchell et

al., 2007; Riddle & Golladay, 2016) reported a significant association between depression and falls. Specifically, there was a significant association between self-reported depression and having at least one fall ($p=0.0025$) (Mitchell et al., 2007), and the Cardiac Depression Scale and having two or more falls ($p=0.007$) (Hill et al., 2016). Self-reported symptoms of depression were also significantly associated with increased falls ($p<0.05$) (Riddle & Golladay, 2016). Depression as measured by the GDS was higher in 25 TKA fallers (GDS: 5.4 ± 2.6) compared to 75 TKA non-fallers (GDS: 3.4 ± 2.5) before surgery; however, depression was not independently predictive of pre-operative falls (Swinkels et al., 2008). One cross-sectional study of 54 older patients with TKA found no significant difference in GDS scores between fallers and non-fallers ($p=0.459$); however, the quality of the methodology was rated as "poor".

Number of Comorbid Conditions. The association between the number of comorbid conditions and falls is not clearly delineated in the TJA literature. Three of the five studies (Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016) that specifically examined comorbid conditions and falls reported no differences in co-morbid conditions between fallers and non-fallers before (Swinkels et al., 2008; Tsonga et al., 2015) and after (Tsonga et al., 2016) surgery for TKA. The remaining studies reported that the number of comorbid conditions was significantly higher in pre-operative fallers and non-fallers (Ikutomo et al., 2015; Mitchell et al., 2007). In a cross-sectional study of 199 pre-operative TJA patients, the odds of falling were 2.21 (95% CI: 1.03, 4.80, $p<0.05$) with two or more comorbid conditions as compared to those with no comorbid conditions after adjusting for sex and gender (Mitchell et al., 2007). In THA patients who had fallen in the last year ($n=79$), 39% had no comorbidities compared to 53% ($n=137$) of non-fallers; this difference was significant ($p=0.044$) (Ikutomo et al., 2015).

Medications. Few studies addressed medications and falls in TJA patients with mixed conclusions on the association between the use of multiple medications and falls. Six (Ikutomo et al., 2015; Matsumoto et al., 2012; Mitchell et al., 2007; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016) studies that examined the number of medications between fallers and non-fallers were inconclusive. Of the two studies that examined antidepressant medication, one cross-sectional study reported a higher proportion of TJA patients taking antidepressants in those with a past history of falls (13/75; 17%) as compared to those who had not fallen (8/119; 7%) (p=0.02) (Mitchell et al., 2007); however, Swinkels and colleagues (2008) in a high quality longitudinal study concluded that uptake of antidepressants did not increase the risk of falling after adjusting for age, gender, number of comorbid conditions and pre-operative scores (OR: 1.18, 95% CI: 0.159, 0.878). Bisphosphonate use was reported to increase the risk of falling by 28% (OR: 1.28, 95% CI: 1.03, 1.58, p=0.02) in THA patients (n=104) (Smith et al., 2016). Of the articles included in this scoping review, there is agreement that the number of prescribed regular medications does not differ significantly between fallers and non-fallers (Matsumoto et al., 2012; Mitchell et al., 2007; Swinkels et al., 2008).

3.5 Discussion

Twelve articles were included in this review that specifically examined falls in patients with TJA. Falls in TJA patients is an emerging area of interest, with 10 of the 12 studies published after 2010. The review suggests that TJA patients have a greater risk of falling as compared to healthy community dwelling seniors, and the increased risk of falls may be linked to functional outcome such as range of motion and fear of falling. The majority of articles were small, single-center studies of low to moderate quality. Most studies examined TKA patients

(Hill et al., 2016; Levinger et al., 2011; Mitchell et al., 2007; Riddle & Golladay, 2016; Smith et al., 2016; Soison et al., 2014; Swinkels et al., 2008; Tsonga et al., 2015; Tsonga et al., 2016) while only 2 studies examined THA patients exclusively (Ikutomo et al., 2015; Pozzi et al., 2015). Three studies examined both TKA and TJA (Hill et al., 2016; Mitchell et al., 2007; Smith et al., 2016). In the longitudinal studies that looked at falls in patients before and after surgery, TJA patients waiting for surgery have more reported falls compared to TJA patients recovering from surgery.

The pattern of fall trajectories during the perioperative period is understudied. A patient waiting for a TJA may be at a higher risk of falls due to functional limitations such as increased pain and disability. Alternatively, the period of time immediately after surgery may put patients at an increased risk of in-hospital falls, due to limited mobility (Memtsoudis et al., 2012). Up to 17% of patients admitted for short-term hospitalization reporting a fall while in the hospital (Memtsoudis et al., 2012), with TKA patients reporting a higher incidence of in-hospital falls as compared to THA patients (Mandl et al., 2013). Several studies have shown the risk of falling increases dramatically as the number of risk factors increase (Delbaere et al., 2010; Tinetti et al., 1988). In addition to balance deficits, pre-operative OA patients also have knee and hip pain, and severe pain is one of the distinguishing factors that separate severe, end-stage OA patients from those that do not undergo TJA. Living with persistent pain increases the risk of falls. Our scoping review found in one study, 40% (n=282) of pre-operative TJA patients cite pain as a contributor to their falls (Hill et al., 2016). It is possible that high levels of self-reported pain in pre-operative TJA patients partially accounts for the high prevalence of falls in this subgroup. This conclusion is supported by several studies in the literature, where a recent cross-sectional survey of 1,600 older women found those with knee pain or back pain had a higher incidence of falls over a 12-

month period (Muraki et al., 2011). In addition, Patel and colleagues (2014) found in a study of 7,601 participants, prevalence of multiple falls was higher in older adults with pain as compared to those without pain. Presence of knee and hip pain may potentially explain the increased risk of falling in pre-operative patients compared to post-operative patients.

Although several outcomes in this scoping review were heterogeneous, the three studies that examined range of motion, extension, and flexion scores (Matsumoto et al., 2012; Pozzi et al., 2015; Soison et al., 2014) concluded these factors were significant predictors of falls. Specifically, patients with a 10-degree increase in motion knee and ankle range of motion reduced the odds of falling by 72.3% (OR: 0.28; 95% CI: 0.09, 0.87) at 1-year post op (Matsumoto et al., 2012). These findings support the current evidence in the literature, where a prospective study found a significant decrease in range of motion (ROM) of hip extension, internal rotation, and ankle dorsiflexion in fallers as compared to non-fallers (Chiacchiero, Dresely, Silva, DeLosReyes, & Vorik, 2010), suggesting a link between ability to maintain balance, decreased range of motion, and falls in TJA patients. Post-operative function such as knee flexion angle can recover beyond pre-operational levels in less than one month, however, when compared with age-matched healthy controls without TJA, patients with TJA have greater physical impairments and functional limitations even 1 year after surgery (Walsh, Woodhouse, Thomas, & Finch, 1998). Although risk for falls is potentially lowered after surgery, due to the combined effects of several risk factors in those with OA, our scoping review found that TJA patients before and after surgery are still more likely to fall than their community dwelling counterparts without arthritis.

Fear of falling is an independent predictor of future falls in OA patients. Although TKA may relieve pain and restore self-reported function in patients with advanced stage OA, fear of

falling and activity restriction, both of which are risk factors for falls, continue to be problematic for this patient population. One study reported fear of falling and cognitive functioning at six weeks after surgery to be more important than ratings of pain and depression in predicting functional outcomes after TJA (Voshaar et al., 2006). Specifically, a higher fear of falling after a THA is related to a less favourable functional outcome, independent of age and pre-morbid level of functioning. In another systematic review of 35 studies, an individual's cognitive state such as an individual's perception of their general health and pain was found to consistently predict multiple functional outcomes after TJA (Vissers et al., 2012). More importantly, a large prospective study demonstrated an association between low self-efficacy as measured with the FES and a higher degree of functional decline over time (de Leon, Carlos F Mendes, Seeman, Baker, Richardson, & Tinetti, 1996). Since fear of falling is one of the few modifiable risk factors for falls, adding cognitive behavioural interventions aimed at reducing fear of falling may be beneficial to improve long term functional outcomes in TJA patients post surgery (Zijlstra et al., 2007).

There are several limitations of scoping review that should be considered when drawing conclusions from the studies included in the review. The primary aim of this review was to determine the scope of the literature that assessed falls and fear of falling in older adults, and formal assessment of methodological quality did not rule out any studies. Of the 12 articles identified, the majority of studies were of low (Ikutomo et al., 2015; Mitchell et al., 2007; Pozzi et al., 2015; Soison et al., 2014) or moderate (Hill et al., 2016; Levinger et al., 2011; Smith et al., 2016; Tsonga et al., 2015; Tsonga et al., 2016) quality. More than half of the studies included in this review had sample sizes (<118) and took place at a single clinic or hospital, which can increase the risk of type II errors. Hence the heterogeneity of the TJA populations does not lead

to clear conclusions of risk factors for falls in THA or TKA. Another limitation is how falls were documented. All studies used retrospective self-report of falls, which could lead to under-reporting, especially if the recall time is longer than 12 months (Hale et al., 1993). Monthly falls diaries have been cited as the most validated method of collecting falls data (Ganz, Higashi, & Rubenstein, 2005; Hale et al., 1993), however only two studies (Matsumoto et al., 2012; Pozzi et al., 2015) used this method.

3.6 Conclusions

Few studies specifically addressed the prevalence of falls in patients with TJA. Larger, prospective studies representative of this patient population are needed to examine the prevalence and the associated risk factor of falling in patients progressing towards TJA compared to patients recovering from TJA

Tables and Figures

Table 3-1 Articles included in the scoping review, summarizing the prevalence of falls and falls risk factors in total joint arthroplasty participants

Author	Sample Characteristics	Surgery Type	Study Design	Falls Prevalence and Circumstances	Measures	Results	Quality of Study
Hill et al. (2016) *Australia*	n=282 Age: 67.3 (SD 8.6) years Female n =155 (55%)	Hip (n=85) Knee (n=197) Total (n=282)	Cross sectional	**Pre-Op** (2-4 Weeks Before Surgery) Self-Report, Recall Time: 12 Months **Prevalence**: 116 (41%) had one fall or more in the past 12 months **Circumstances of the falls:**			Acceptable

Falls Prevalence and Circumstances

First Fall		*n (%)*
"What was the time of the fall"?	Midnight to 11.59 AM	47 (40.9%)
	Noon to 5.59 PM	44 (38.3%)
	6:00PM to 11:59PM	11 (9.6%)
"Where did the fall occur"?	Not home, outside	42 (36.5%)
	At home outside.	39 (33.9%)
"Was the fall related to the painful joint"?	Yes	40 (35%)
"How did the fall occur"?	Trip	59 (49.6%)
	Slip	27 (23.5%)
	Legs gave way	18 (15.7%)

Results

Measures	*Knee Replacement Patients (n=197)*			*Hip Replacement Patients (n=85)*		
	No Falls	*>1 Falls*	*p*	*No Falls*	*>1 Falls*	*p*
Falls Efficacy Scale: International 7-28 (7: no concern) High WOMAC (>1105) Low WOMAC (<1105)	11.4 (3.8)	13.5 (5.6)	0.005	11.3 (4.3)	13.6 (4.0)	0.121
	High WOMAC	*Low WOMAC*		*High WOMAC*	*Low WOMAC*	
	13.7 (4.6)	10.6 (3.5)	<0.01	13.6 (5.3)	10.7 (3.1)	0.002
Activities- Specific Balance Confidence Scale 0-100 (0: least fearful) High WOMAC (>1105) Low WOMAC (<1105)	*No Falls*	*>1 Falls*	*p*	*No Falls*	*>1 Falls*	*p*
	71.2 (22.1)	63.8 (20.6)	0.051	70.8 (23.5)	59.8 (23.6)	0.272
	High WOMAC	*Low WOMAC*		*High WOMAC*	*Low WOMAC*	
	62.1 (21.9)	75.3 (19.8)	<0.01	61.3 (24.2)	74.6 (61.3)	0.

	Knee Replacement Patients (n=197)			
	No Falls	*Single Falls*	*>1 Falls*	*p-value*
WOMAC Function, VAS Scale 0-1700 (0: no difficulty with function)	671.7 ± 280.0	676.7 ± 317.1	807.4 ± 282.00	p=0.020*
Self-perceived quality of life (SF-36 Mental) 0-100 (0: lowest quality)	54.9 ± 9.7	55.9 ± 8.5	50.6 ± 13.1	p=0.030*
Pain (Pain Catastrophizing Scale) 0-52 (0:least catastrophizing)	11.1 ± 9.5	8.5 ± 7.0	14.4 ± 11.5	p=0.021**
Cardiac Depression Scale (CDS) 26 – 182 (26: least depressive mood)	S68.2 ± 21.2	68.1 ± 17.0	79.5 ± 23.9	p=0.007*

				"Were any specific obstacles involved"?	Slippery surface No obstacles involved Steps	19 (16.5%) 17 (14%) 16 (13.9%)	** One-way ANOVA post hoc: significant difference between multiple fallers and other groups* *** One-way ANOVA post hoc: significant difference between all three groups* Measures that were not significant: In TKA patients, WOMAC pain (p=0.664), WOMAC Stiffness (p=0.396), WOMAC total (p=0.131), SF-36 Physical Component Score (p=0.150), Tampa Scale for Kinesiophobia (p=0.863) IPEQ Incidental Activity (p=0.897), IPEQ planned activity (p=0.093), and IPEQ total activity (p=0.50) were not significantly different between non-fallers and multiple fallers. In THA patients, no measures were significantly different between non-fallers and multiple fallers. WOMAC pain (p=0.74), WOMAC stiffness (p=0.53), WOMAC function (p=0.14), WOMAC total (p=0.53), Pain Catastrophizing Scale (p=0.73), SF-36 Physical Component score (p=0.19), SF-36 Mental Component Score (p=0.95), Tampa Scal for Kinesiophobia (p=0.45), Cardiac Depression Scale (p=0.59), IPEQ incidental (p=0.54), IPEQ planned (p=0.54) and IPEQ total (p=0.44)	
				"Using any glasses/spectacles at the time of the fall"?	No, Trifocals/multifocal Bifocals	53 (45.7%) 26 (22.4%) 12 (11.2%)		
				"Medication sought"?	Did not seek General practitioner Hospitalized	99 (89.2%) 7 (6.3%) 4 (3.6%)		
Mitchell et al. (2007) *United Kingdom*	n = 199 Age: 72 (95% CI: 71.6-72.7) years Female 111 (55.6%)	Hip (n=84) Knee (n=115)	Cross Sectional	**Pre-Op** (Waitlist to Receive Surgery*) Self-Report, Recall Time: 4 Weeks **Prevalence**: 75 (39%) of pre-op patients fell *Specific timeframe not reported				Poor

	0 Falls	*≥ 1 fall*	*p-value*
WOMAC Pain* (Likert, transformed to 0-100 scale) 0 – 100, 0 least pain	45	33	0.0012
WOMAC Function* (Likert, transformed to 0-100 scale) 0 – 100, 0 no difficulty with function	41	33	0.0001
Self-perceived quality of life -36 *			
Physical Functioning	28	20	<0.05
Bodily Pain	33	25	<0.05
Role Physical	17	7	<0.05
General Health	60	52	<0.05
Vitality	48	40	<0.05
Role Emotional	56	36	<0.05

** Range not reported*

Timed Up and Go – mean (95% CI)	16 (14.9, 17.0)	19.8 (16.8, 22.8)	0.02
Hypnotic/Antidepressant Medication – N (95% CI)	8/119 (7)	13/75 (17)	0.02
Number of Comorbid Conditions – mean (95% CI)	1.9 (1.6, 2.1)	2.6 (2.2, 3.0)	0.0025
Self-Reported Depression – N (95% CI)	14/115 (12)	17/69 (25)	0.0025
Number of Geriatric Problems – mean (95% CI)	1.2 (0.9, 1.4)	1.8 (1.5, 2.1)	0.0016
Self-Reported Memory Problem – N (95% CI)	11/114 (10)	17/72 (24)	0.010
Self-Reported Balance Problem – N (95% CI)	37/114 (33)	42/72 (58)	0.0005

Measures that were not significant: WOMAC stiffness (p>0.05), SF-Social Functioning (p>0.05), SF-Role Emotional (p>0.05), age (p=0.67), sex (p=0.36), joint being replaced (p=0.16), osteoporosis at any site (p=0.58), use of parathyroid hormone (p=0.06), use of vitamin D (p=0.26), BMI (p=0.14), and number of prescription medications ([=0.057) were not statistically different between non-fallers and fallers.

	Adjusted OR (for sex and gender) for factors associated with falling	*p-value*
Number of comorbid conditions > 2	2.2 (1.03, 4.8)	<0.05
Self-reported balance problem	2.5 (1.2, 5.1)	<0.05

Measures that were not significant: Self reported depression (Adjusted OR: 21.0, 0.4-2.8), Hypnotic/antidepressant medication (2.4, 0.7-7.9), more than one geriatric problem (0.9, 0.4-2.1), and self-reported memory problem (2.7, 0.9-8.0) were factors that were not significantly associated with falling (p <0.05)

<table>
<tr>
<td>Pozzi et al (2015)
(2015)
USA</td>
<td>n=31

Age: 65 (SD:8) years

Female 31 (100%)</td>
<td>Hip (n=31)</td>
<td>Cross Sectional</td>
<td>Pre-Op (2 weeks before surgery)

Self Report "have you had a fall in the previous 6 months?" Recall time= 6 Months

Prevalence: 7 (22.5%) of pre-op patients reported at least one fall within 6 months of survey</td>
<td>
<table>
<tr><th></th><th>No Falls (n=7)</th><th>≥ 1 Falls (n=24)</th><th>t-test</th><th>Correlation with fall (r, p-value)</th></tr>
<tr><td>Age</td><td>63 ± 8</td><td>71 ± 6</td><td>0.01</td><td>0.4, 0.03</td></tr>
<tr><td>Timed up and go (s)</td><td>10.9 ± 3.43</td><td>17.63 ± 11.13</td><td>>0.01</td><td>0.45, 0.01</td></tr>
<tr><td>Stair climbing (s)</td><td>22.64 ± 9.07</td><td>41.4 ± 20.4</td><td>>0.01</td><td>0.54, >0.01</td></tr>
<tr><td>6 minute walk test (m)</td><td>399.16 ±86.19</td><td>264.36 ± 145.85</td><td>>0.01</td><td>-0.5, >0.01</td></tr>
<tr><td>Total hip ROM, degrees</td><td>156.08 ± 26.94</td><td>135.85 ±13.45</td><td>0.03</td><td>-0.33, 0.06</td></tr>
<tr><td>Knee extension on surgical side of hip, Nm/Kg</td><td>2.15 ± 1.13</td><td>1.33 ± 0.63</td><td>0.04</td><td>-0.32, 0.08</td></tr>
<tr><td>Knee extension on non-surgical side of hip, Nm/Kg</td><td>1.04 ± 2.19</td><td>2.08 ± 1.24</td><td>0.04</td><td>-0.31, 0.08</td></tr>
</table>
Measures that were not significant: BMI (p=0.41), Hip Harris Score (p=0.26), Hip Outcome Score (p=0.31), low back pain on a 1-10 scale (p=0.07), hip pain on 1-10 scale on both surgical and non-surgical side (p=0.33, p=0.08), knee pain on 1-10 scale on surgical and non-surgical side (p=0.06, p=0.2), knee abductor strength on surgical and non-surgical side (p=0.06, p=0.14) are all not significantly different between participants that had no falls and participants that had ≥ 1 falls.
</td>
<td>Poor</td>
</tr>
<tr>
<td>Tsonga et al (2015)

Greece</td>
<td>n=68

Age: 73 (SD:5.8) years

Female 57 (83.8%)</td>
<td>Knee (n=68)</td>
<td>Cross Sectional</td>
<td>Pre-Op (approximately 1 month prior to surgery) patients with severe knee OA grade 3 and 4

Self Report, Recall Time: 12 Months

Prevalence: 43 (63.2%) had one or more falls in the past 12 months

Circumstances of the falls:
<table>
<tr><th>First Fall</th><th></th><th>n (%)</th></tr>
<tr><td>Activity during falling</td><td>Ambulating
Stair climbing
Reaching</td><td>58 (89.23)
5 (7.69)
1 (1.54)</td></tr>
<tr><td>Location of fall</td><td>Indoor
Outdoor</td><td>16 (24.62)
49 (75.38)</td></tr>
<tr><td>Mechanism of fall</td><td>Stumble-Triple
Slip
Lost balance
Muscle weakness</td><td>27 (41.5%)
14 (21.54)
18 (15.7%)
20 (30.77)</td></tr>
</table>
</td>
<td>
Total score of questionnaires in patients with severe knee OA grade 3 or 4
<table>
<tr><th>Variable</th><th>Mean ± SD</th></tr>
<tr><td>SF-36 Physical</td><td>34.5 ± 6.99</td></tr>
<tr><td>SF-36 Mental</td><td>36.36 ± 9.83</td></tr>
<tr><td>WOMAC (VAS Scale)</td><td></td></tr>
<tr><td>Total</td><td>822.79 ± 317.31</td></tr>
<tr><td>Pain</td><td>226.10 ± 85.24</td></tr>
<tr><td>Stiffness</td><td>56.62 ± 43.54</td></tr>
<tr><td>Physical function</td><td>540.07 ± 255.18</td></tr>
<tr><td>Timed Up and Go Performance Test (seconds)</td><td>13.05 ± 4.13</td></tr>
</table>
Measures that were not significant: Gender (p=0.102), age (p=0.965), BMI (p=0.783), presence of pain elsewhere the body (0.789), number chronic diseases (<0.999), having a social environment (0.468), previous arthroplasty (p=0.751), SF-36 physical (p=0.734), and SF-36 mental (p=0.787), WOMAC pain (p=0.338), WOMAC stiffness (p=0.605), WOMAC physical function (p=0.882), and the Turn Up and Go (p=0.603) were not significantly diffe between patients who did not fall and patients who fell.
</td>
<td>Acceptable</td>
</tr>
</table>

				Injuries during falling: Fracture 4 (6.15%); Minor Injury 15(23.08%); No Injury 11 (70.77%)		
Levinger et al. (2011) *Australia*	n=62 Age: 66 (SD:7) years Female n =30 (48%)	Knee (n=35) Non-Surgical Controls (n=27)	Prospective Cohort	**Pre-Op*** (n=35) **& Post-Op**** (n=35) (4 Months After Surgery) Self report, recall time = 12 Months **Prevalence:** 17 (48%) of pre-op TKA patients fell 8 (30%) of non-surgical controls fell *Timeframe not reported for pre-op patients **Post-op prevalence of falls not measured	Surgical pre-op / Surgical post-op / Non-surgical control FES-I (7-28 (7: no concern)): 11.4 ± 3.0 *+ / 9.7 ± 2.9* / 7.6 ± 1.2 WOMAC Pain - VAS (range 0-500, 500 worst): 192.5 ± 106.0 + / 171.5 ± 278.2 / - WOMAC Stiffness - VAS (range 0-200, 200 worst): 95.4 ± 46.7 + / 48.6 ± 37.3 / - WOMAC Function - VAS (0-1,700): 609.0 ± 325.9 + / 278.6 ± 236.0 / - WOMAC Total - VAS (0-2,400): 896.9 ± 430.4 + / 498.7 ±498.5 / - Assessment of Quality of Life (AQoL): 0.8 ± 0.0 + / 0.7 ± 0.1* / 0.8 ± 0.1 Incidental and Planned Activity Questionnaire: Incidental: 38.5 ± 19.8*+ / 8.3 ± 14.5* / 19.5 ± 13.9 Incidental and Planned Activity Questionnaire: Total: 44.3 ± 20.6 *+ / 12.1 ± 16.1 / 25.9 ± 16.3 Measures that were not significant: IPAQ planned was not significantly different to control or to post surgery (p>0.05). ** Significantly different to control* *+Significantly different to post-surgery*	Acceptable
Riddle et al. (2016) *USA*	Cases: n=413 Age: 63.9 (SD: 6.8) years Female: 251 (60.7) Controls: n=4,200 Age: 60.8 (9.2) Female: 2,446 (58.2%)	Knee arthroplasty patients (n=413)	Retrospective Cohort	**Pre Op & Post Op** (4 years pre-op to 4 years post-op) Self-report: "during the last 12 months, have you landed on the floor or ground?" Recall time: 1 year **Prevalence:** *Non-arthroplasty OA patients*: Annual single fall rates: 20% for women, 12% for men. *TKA OA patients*: Pre & Post-Op annual single fall rate*: 15-23% for women, 8-13% for men *No clear consistent pattern of increasing or decreasing rates over the pre-operative or post-operative time period	*Year 4 non-KA to 1-year pre-op KA (OR, 95% CI)* / *Year 4 non-KA to 1-year post-op KA (OR, 95% CI)* *1 Fall (reference group: no falls)* Age: 1.00, (0.99,1.01) / 1.02 (1.01, 1.03)* Male Sex: 0.60 (0.49, 0.74)* / 0.83 (0.67, 1.02) No Narcotic Use: 0.63 (0.41, 0.97)* / 0.41 (0.33, 0.50) No Prior Falls: 0.74 (0.47, 1.15)* / 0.78 (0.55, 1.20)* *Other Non-Significant Measures (OR, 95% CI)*: PASE score 1.0 (0.99, 1.00), depressive symptoms 1.00 (0.99, 1.02), repeated chair stand 0.57 (0.28, 1.17), no comorbidity 0.82 (0.66, 1.01), no knee replacement 0.74 (0.47, 1.15) / PASE score 0.83 (0.67, 1.02), depressive symptoms 1.00 (1.00, 1.01), repeated chair stand 1.01, (0.99, 1.02), no comorbidity0.70, (0.34, 1.42), no knee replacement 0.78 (0.55, 1.20) *2+ Falls (reference group: no falls)* Age: 0.98 (0.97, 0.99)* / 0.99 (0.98, 1.01)* Depressive symptoms: 1.05 (1.04, 1.07)* / 1.04 (1.03, 1.05)* No comorbidity: 0.77 (0.60, 0.97)* / 0.80 (0.66, 1.08) No narcotic use: 0.53 (0.34, 0.82)* / 0.89 (0.55, 1.44) No prior falls: 0.16 (0.13, 0.21)* / 0.14 (0.10, 0.18)* *Other Non-Significant Measures (OR, 95% CI)*: Male sex 0.93 (0.74, 1.16), PASE score 1.00 (1.00, 1.00), repeated chair stand 0.76 (0.34, 1.70), no / Male sex 1.24 (0.99, 1.55), PASE score 1.00 (1.00, 1.00), repeated chair stand 0.62 (0.29, 1.32), no knee replacement	Acceptable

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>knee replacement 1.39 (0.91, 2.14) 0.67 (0.36, 1.23)
*p>0.05</td><td></td></tr>
<tr><td>Swinkles et al. (2009)

UK</td><td>n=99

Age: 73.4 (SD: 4.9) years

Female 63 (64%)</td><td>Knee (n=99)

Primary (n=99)</td><td>Prospective Cohort</td><td>Pre Op (1-3 months) & Post Op (1-12 months)

Self report. Recall time: 1 month for 3 months pre-op and for 12 months post-op

Prevalence:

3 Months Pre-Op | 3 Months Post-Op | 6 Months Post-Op | 12 Months Post-Op
Fallers/ Non-Fallers: 24/75 | 11/83 | 11/82 | 11/85

Circumstances of the falls:

Pre Op | Post Op
Patients with 1+ fall: 11 | 9
Total # falls: 44 | 87
No. fallers: 24 | 24
Location - Inside: 20 | 47
Location - Outside: 17 | 40
Intrinsic cause: 13 | 19
Extrinsic cause: 15 | 55
Other: 16 | 13
No injuries: 10 | 37
Cuts/bruises: 31 | 40
Fractures: 2 | 6
Other: 1 | 4

</td><td>3 Months Pre-Op | 3 Months Post-Op | 6 Months Post-Op | 12 Months Post-Op
ABC-UK (0-100, 100 Best): 61.7±25.2 | 66.8±21.8 | 70.0±25.2±25.8 | 72.8±25.6
Fallers: 53.1±26.4 | 64.6±18.7 | 61.2±30.4
Non-Fallers: 64.4±24.3 | 67.6±22.8 | 66.0±23.2 | 76.7±22.7

Pre- Operative Fallers (n=24) | Pre-Operative Non-Fallers (n=75)
ABC – UK (0-100, 100 best): 53.1 ± 26.4 | 64.4 ±24.3
Geriatric Depression Scale (0-15, 15 worst): 5.4 ± 2.6 | 3.4 ± 2.5
WOMAC Pain (Likert) (0-20, 20 worst): 11.7 ± 2.7 | 10.4 ± 3.3
WOMAC Stiffness (Likert) (0-8, 8 worst): 5.4 ± 1.2 | 4.8 ± 1.6
WOMAC Function (Likert) (0-68, 68 worst): 42.7 ± 9.4 | 35.9 ± 11.4
WOMAC Total (Likert) (0-96, 96 worst): 59.5 ± 11.8 | 51.0 ± 15.5
Patients reporting falling 4 months prior to entry onto waitlist for TKA: 12/23 | 4/75

Adjusted OR and 95% CI for Pre-Op Patients

Non-significant measures: female gender 0.056 (0.007-0.437), p=0.006
Non-significant measures: age 1.000 (0.878-1.138), no.of comorbid conditions (1.445, 0.020-0.694), no. of baseline medications 1.190 (0.829-1.708), no.of cardiovascular medications 1.190 (0.829-1.708), uptake of anti-depressants 1.18 (0.159-0.878), self-reported eye problems 0.324 (0.057-1.847), self-reported hearing problems 0.910 (0.249-4.755).

Adjusted OR and 95% CI for Post-Op Patients

Non-significant measures: age 1.119 (0.999-1.253), gender 0.574 (0.168-1.955), no. of comorbid conditions 1.124 (0.771-1.639), no.of baseline medications 0.947 (0.697-1.287), no.of cardiovascular medications 1.184 (0.275-5.102), uptake of anti-depressants 0.836 (0.120-5.842), self-reported eye problems 0.719 (0.194-2.659), self-reported hearing problems 1.041 (0.288-3.767).</td><td>High</td></tr>
<tr><td>Tsonga et al (2016)</td><td>n=68

Age: 73</td><td>Knee (n=68)</td><td>Prospective Cohort</td><td>Pre Op (2 Weeks) & Post Op (1-12 months)</td><td></td><td>Acceptable</td></tr>
</table>

<table>
<tr>
<td>Greece</td>
<td>(SD:5.28) years

Female: 57 (83.8%)</td>
<td></td>
<td></td>
<td>Self report. Recall time= 1 month

Prevalence:

Post-op Fall Status at 1 year
<table>
<tr><td>Pre-Op</td><td></td><td>0 Fall</td><td>1 Fall</td><td>1+ Fall</td><td>Totals</td></tr>
<tr><td rowspan="4">Fall Status</td><td>0 Fall</td><td>23 (34%)</td><td>1 (2%)</td><td>1 (2%)</td><td>25 (37%)</td></tr>
<tr><td>1 Fall</td><td>16 (24%)</td><td>2 (3%)</td><td>2 (3%)</td><td>20 (29%)</td></tr>
<tr><td>1+ Fall</td><td>14 (21%)</td><td>7 (10%)</td><td>2 (3%)</td><td>23 (34%)</td></tr>
<tr><td>Totals</td><td>53 (78%)</td><td>10 (14%)</td><td>5 (7%)</td><td>68 (100%</td></tr>
</table>
</td>
<td>
<table>
<tr><td></td><td>Pre-operatively</td><td>Post-operatively (1 year)</td><td></td></tr>
<tr><td>Fear of Falling (Yes)</td><td>56 (82.4%)</td><td>30 44.1%</td><td><0.001</td></tr>
<tr><td>Fear of Falling –Activities Specific Balance Confidence Scale (0-100, 0 least confidence)</td><td>63.76 (20.14)</td><td>81.49 (16.24)</td><td><0.001</td></tr>
<tr><td></td><td>Fallers at 1 year post-op</td><td>Non-Fallers at 1 year post-op</td><td></td></tr>
<tr><td>Fear of Falling –Activities Specific Balance Confidence</td><td>79.50 ± 13.99</td><td>82.05 ± 16.90</td><td>0.595</td></tr>
<tr><td>Fearful of Falling (Yes/No)</td><td>11 (73.3%)</td><td>19 (35.8%)</td><td>0.017</td></tr>
<tr><td>History of Falls (Yes/No)</td><td>12 (30.2%)</td><td>30 (69.8%)</td><td><0.0005</td></tr>
<tr><td colspan="4">Non Significant Measures: Age (p=0.097), Gender (p=0.433), BMI (p=0.720), pain elsewhere in the body (p=0.2 chronic diseases (p=1.000), complications during surgery (0.303), social environment (1.000), presence of social environment (p=1.000), previous arthroplasty surgery (p=0.721), SF-36 Physical (p=0.972), SF=26 Mental (p=0.3 WOMAC pain (p=0.936), WOMAC stiffness (p=0.523), WOMAC physical function (p=0.240), PASE physical activity questionnaire (p=0.971), TUG (p=0.758), and Berg balance scale (p=0.926) were not significantly differe between fallers and non-fallers at 1 year post-op.</td></tr>
<tr><td></td><td>O.R (multiple logistic regression of falling status at 1 year post-op) – stepwise method</td><td>95% CI</td><td></td></tr>
<tr><td>Age</td><td>1.13</td><td>0.98-1.30</td><td>0.084</td></tr>
<tr><td>Fear of Falling</td><td>11.90</td><td>2.20-64.20</td><td>0.004</td></tr>
<tr><td>Falling Status</td><td>7.23</td><td>1.28-41.01</td><td>0.025</td></tr>
</table>
</td>
<td></td>
</tr>
<tr>
<td>Ikutomo et al (2015)

Japan</td>
<td>n=214

Age: 66 (SD:8.7) years

Female 203 (95%)</td>
<td>Hip (n=214)</td>
<td>Cross Sectional</td>
<td>Post-Op (1 year after surgery)

Self Report. Recall time =12 months

Prevalence:
77 (36%) of post-op patients fell</td>
<td>
<table>
<tr><td></td><td>Non-Fallers</td><td>Fallers</td><td>p-value</td></tr>
<tr><td>Age (years)</td><td>86.3 ± 8.2</td><td>64.7 ± 8.7</td><td>0.004</td></tr>
<tr><td>Height (cm)</td><td>153 ± 6.2</td><td>154.8 ± 5.9</td><td>0.037</td></tr>
<tr><td>Medication, n (%)</td><td>63 (81.8)</td><td>69 (50.4)</td><td><0.001</td></tr>
<tr><td>Less than one comorbid medical condition, n (%)</td><td>30 (39)</td><td>73 (53.3)</td><td>0.044</td></tr>
<tr><td>Post-operative duration, years (interquartile range)</td><td>4 (2-7)</td><td>5 (2-8)</td><td>0.023</td></tr>
<tr><td>Total Oxford Hip Score</td><td>16 (14-19)</td><td>14 (12-17)</td><td><0.001</td></tr>
<tr><td>Use of a walking aid, n (%)</td><td>27 (35.1)</td><td>25 (18.2)</td><td>0.006</td></tr>
<tr><td>Walking capacity –“can you walk for more than 60 minutes without stopping?” n (%)</td><td>32 (41.6)</td><td>88 (64.2)</td><td>0.001</td></tr>
<tr><td colspan="4">Measures that were not significant: Sex (p=0.335), body weight (p=0.438), BMI (0.753), THA side (0.215) were not different between non-fallers and fallers.</td></tr>
<tr><td></td><td colspan="2">Adjusted OR (for sex and gender) for factors associated with falling</td><td></td></tr>
<tr><td>Medications</td><td colspan="2">4.09 (1.90-8.80)</td><td><0.001</td></tr>
<tr><td>Post Operative Duration, years</td><td colspan="2">0.89 (0.81-0.98)</td><td>0.014</td></tr>
</table>
</td>
<td>Poor</td>
</tr>
</table>

<table>
<tr>
<td>Matsumoto (2012)

Japan</td>
<td>n=74

Age: 75 (SD:6) years

Female: 57 (88%)</td>
<td>Knee (n=70)</td>
<td>Prospective Cohort</td>
<td>Post Op (6-11 months)

Self-report using monthly fall post-cards (“Did you fall during this month?”). Recall time=1 month, for 6 months

Prevalence:
23 (32.9) fell once or more during 6-month observation period</td>
<td>
<table>
<tr><th></th><th>Fallers</th><th>Non-Fallers</th><th>p-value</th></tr>
<tr><td>Modified Falls Efficacy Scale (M-FES)</td><td>122.2 27.1</td><td>123.3 23.3</td><td>0.874</td></tr>
<tr><td>Post operative flexion</td><td>10.2 ± 16.1</td><td>119.5 ± 14.1</td><td>0.016</td></tr>
<tr><td>Post operative flexion and extension</td><td>100.6 ± 18.4</td><td>109.7 ± 15.9</td><td>0.037</td></tr>
<tr><td>ROM of the ankle (°) – plantar flexion</td><td>55.2 ± 6.1</td><td>59.1 ± 6.1</td><td>0.014</td></tr>
</table>
Measures that were not significant: age (p=0.156), gender (p=0.766), height (p=0.435), weight (p=0.494), BMI (p=0.142), TKA side (p=0.969), diagnosis of OA or RA (p=0.730), mean time since surgery (p=0.444), prior hip surgery (p=0.986), total number of prescribed medications (p=0.843), hearing problems (p=0.533), eye problems (p=0.051), cardiac disease (p=0.065), diabetes (p=0.058), hypertension (p=0.422), ambulation (p=0.466), pre-operative ROM of the knee flexion (p=0.055), pre-operative ROM of the knee extension (p=0.561), pre-operative range of flexion and extension (p=0.105), post operative extension (p=0.850), dorsal flexion of the ankle (p=0.070), instability on a 0-3 scale (p=0.384), muscle strength of knee extension (p=0.816), hallux valgus on a 1 to 4 scale (p=0.867), limitation of ankle mobility (p=0.960), kyphosis (p=0.350), one-leg stand (p=0.578), speed in 10 minute gait test (p=0.612), step length in 10 minute gait test (p=0.686), JKOM total score (p=0.601), VAS (p=0.342), pain (p=0.985), limitation of activity (p=0.449), restriction of participation (p=0.679), and geriatric depression scale (p=0.459), were not statistically different between fallers and non-fallers.
<table>
<tr><th></th><th>OR (95% CI)</th><th>p-value</th></tr>
<tr><td>Range of knee flexion (post op) (10 degree groups, 80-140)</td><td>0.277 (0.088-0.869)</td><td>0.028</td></tr>
<tr><td>Range of knee flexion and extension (post op (10 degree groups, 60-135)</td><td>2.308 (0.847-6.289)</td><td>0.102</td></tr>
<tr><td>Range of ankle plantar flexion (5 degree groups, 40-70)</td><td>0.594 (0.374-0.945)</td><td>0.028</td></tr>
</table>
</td>
<td>High</td>
</tr>
<tr>
<td>Soison et al (2014)

Thailand</td>
<td>n=54

Age: 67 (SD:8) years

Female 46 (85%)</td>
<td>Knee (n=54)</td>
<td>Cross Sectional</td>
<td>Post-Op (38.9 ± 16.6 or 7-73 months)

Self-report. Recall time = 12 months

Prevalence:
23 (42%) of post-op patients fell

Circumstances of the falls:
<table>
<tr><th>Fall</th><th>Cases or Times</th></tr>
<tr><td>Total number of falls (range)</td><td>34 (1-4)</td></tr>
<tr><td>Period(s) of falls (time)</td><td></td></tr>
<tr><td>Morning</td><td>11</td></tr>
<tr><td>Afternoon</td><td>13</td></tr>
<tr><td>Evening</td><td>8</td></tr>
<tr><td>Night</td><td>2</td></tr>
<tr><td>Places of falls (cases/times)</td><td></td></tr>
<tr><td>Inside the house:</td><td>13/13</td></tr>
<tr><td>Outdoors: other</td><td>20/21</td></tr>
<tr><td>Poor lighting</td><td>2</td></tr>
<tr><td>Poorly arranged furniture</td><td>1</td></tr>
<tr><td>Slippery surface</td><td>7</td></tr>
<tr><td>Other</td><td>2</td></tr>
</table>
</td>
<td>
<table>
<tr><th></th><th>Non-Fallers</th><th>Fallers</th><th>p-value</th></tr>
<tr><td>Height (cm)</td><td>156.06 ± 7.29</td><td>154.26 ± 4.22</td><td><0.005</td></tr>
<tr><td>Limited Knee Joint Motion (case)</td><td>2</td><td>7</td><td><0.05</td></tr>
</table>
Measures that were not significant*: Age, weight, BMI, time after surgery, VAS, WOMAC pain, stiffness, function, total, satisfaction score (maximum score 10), visionproblems

* exact p-values not reported, all >0.05
<table>
<tr><th></th><th>Coefficient of association between risk factor and falls</th><th>Standard Error</th><th>p value</th></tr>
<tr><td>WOMAC Pain</td><td>0.048</td><td>0.021</td><td><0.05</td></tr>
<tr><td>WOMAC Stiffness</td><td>0.141</td><td>0.049</td><td><0.025</td></tr>
<tr><td>Limit Knee Joint Motion (flexion <120° and/or joint was not able to fully extend 0°)</td><td>0.594</td><td>0.227</td><td><0.025</td></tr>
</table>
Measures that were not significant: Sex (p=0.320), vision problems (p=0.792), weight (p=0.993), height (p=0.696), BMI (p=0.854), VAS (p=0.317), WOMAC function (p=0.109), total WOMAC (p=0.070).
</td>
<td>Poor</td>
</tr>
<tr>
<td>Smith et al (2014)</td>
<td>n=269

Age: 67</td>
<td>Hip (n=104)</td>
<td>Retrospectiv e</td>
<td>Post-Op (12-72 months after surgery)</td>
<td>
<table>
<tr><th></th><th>Falls in THA patients</th><th>Falls in TKA patients</th></tr>
<tr><td>Bisphosphonate use (OR, 95% CI:</td><td>1.28 (1.03, 1.58) 0.02</td><td>1.23 (1.03, 1.58) 0.03</td></tr>
</table>
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<td>Acceptable</td>
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United Kingdom	(SD:9) years Female 112 (41.6%)	Knee (n=165)	Cohort	Self report. Recall time=12 months **Prevalence:** 26 (25%) of post-op THA patients fell at least once 43 (26.1%) of post-op TKA patients fell at least once	*p* value) Knee OA in the past (OR, 95% CI: *p* value) Measures that were not significant:	1.51 (1.06, 2.04) 0.02 Age (0.99, 0.98-1.00), gender (0.87, 0.74-1.02), marital status 1.00 (0.94, 1.27), employment (1.07, 0.89-1.27), hip OA in the past (1.00, 1.04-1.20), race (0.94, 0.78-1.13)	- age (1.00, 0.99-1.00), gender (0.89, 0.76-1.00), marital status (1.01, 0.95-1.07), employment 0.86 (0.56-1.30), previous hip arthroplasty (1.61, 0.64-4.08), diagnosis of hip OA 1.34 (0.93-1.94), diagnosis of knee OA (0.96, 0.76-1.21), race (1.05, 0.87-1.27)	

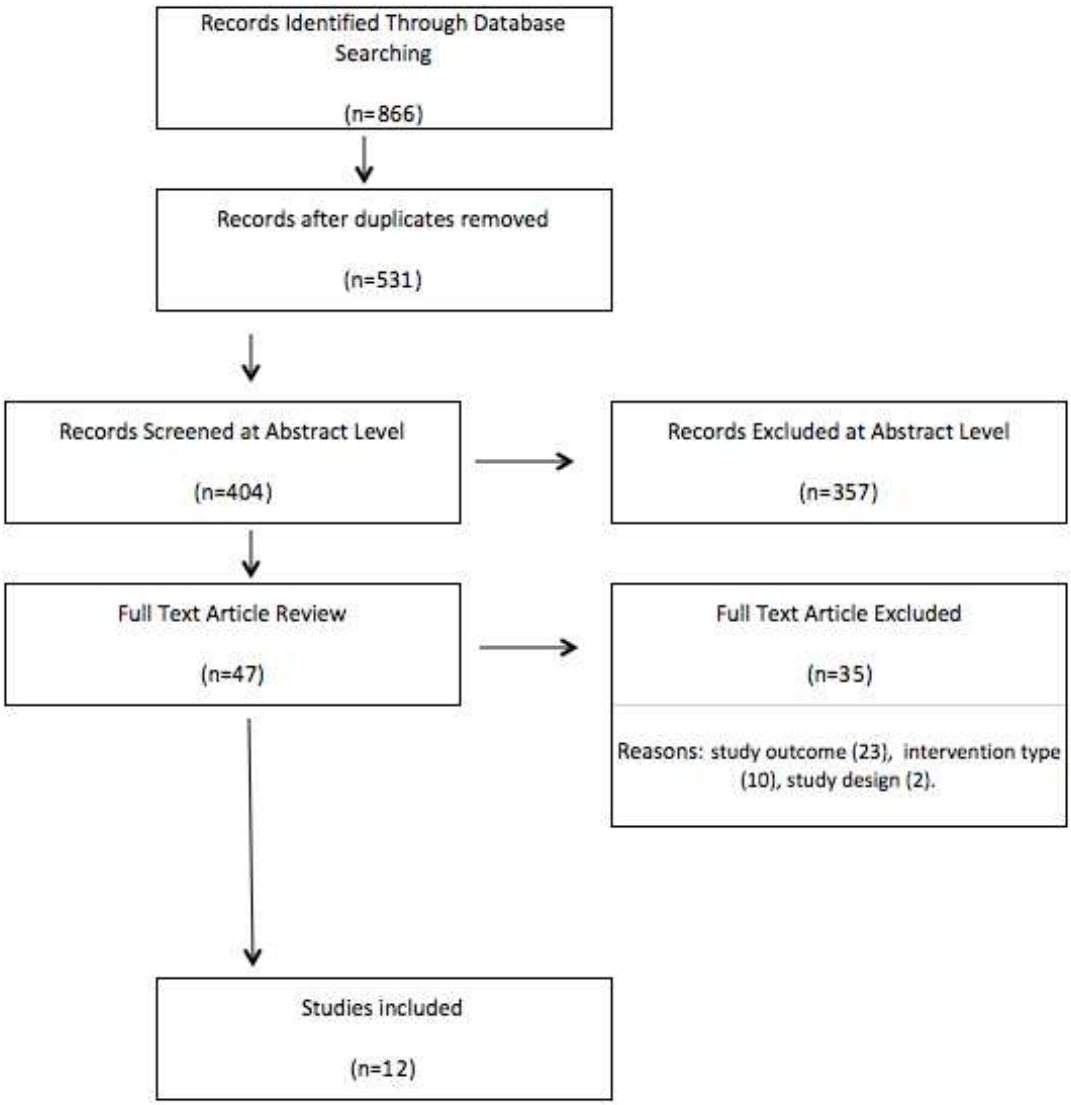

Figure 3-1 Prisma table

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Falls and Fear of Falling in Older Adults with Total Joint Arthroplasty

Authors

Serena Kuangyi Chen BSc, University of Alberta, Edmonton Alberta, T6G 2G4, serenaku@ualberta.ca

Don Voaklander, PhD, School of Public Health, University of Alberta, Edmonton, Alberta, T6G 2G4 dvoaklander@ualberta.ca

C. Allyson Jones, PhD, Dept Physical Therapy, University of Alberta, Edmonton, Alberta T6G 2G4 cajones@ualberta.ca

Keywords: Total Joint Arthroplasty, Accidental Falls, Fear of Falling

4.1 Abstract

Objective: Falls in patients with total joint arthroplasty (TJA) patients has not been studied extensively, with conflicting reports of associated falls risk factors. The specific objectives are to examine a) reported falls and the fear of falling in TJA patients compared to community controls and b) to determine what established risk factors are associated with falls in the TJA cohort, and if these risk factors are different from those seen in the community controls.

Methods: This cross-sectional study included older adults over the age of 60 years with TJA (n=198), and controls from the community (n=100). Fear of falling was measured using the Activities-specific Balance Confidence scale (ABC). Multivariable logistic regression was used to determine factors associated with falls in TJA participants.

Results: In the TJA group, 29% (n=57) reported falls over the past year, 13 (25%) were recurrent fallers. Of the 24 (n=24) controls who reported falls, 6 (6%) were recurrent fallers. The mean number of measured risk factors for falling was significantly higher for the TJA group (6.3±3.2) as compared to community controls (3.7±2.5), $p<0.001$. Fear of falling was greater in the TJA group (Activities-specific Balance Confidence) mean score 67.0 ± 24.3) than the community controls (88.1±14.9) ($p<0.001$). Having more than three comorbid conditions (TJA OR: 2.2, 95% CI: 1.5, 6.5; Community OR: 1.4, 95% CI: 1.1, 7.5) was associated with falls in community controls and TJA participants. Self-reported chronic pain (OR: 2.1, 95% CI: 1.1, 2.9), high blood pressure (OR: 2.0, 95% CI: 1.1, 3.9), fear of falling (OR: 2.3, 95% CI: 1.2, 4.6), use of more than four medications (OR: 3.7, 95% CI: 1.1, 12.1), and use of a walker compared to no reported use of a walker (OR: 2.6; 95% CI: 1.2, 5.6) were associated with falls in the TJA group only. Urinary incontinence (OR: 5.1, 95% CI: 1.1-22.4), mental health problems (OR: 8.0, 95% CI: 1.3-50, 0.03), use of anti-depressants (OR: 5.9, 95% CI: 1.1-31.5), use of a cane (OR:

7.6 (95% CI: 1.7, 35), and self-report being moderately or very active as compared to not active/a bit active (OR: 4.4, 95% CI: 1.6-12) was significantly associated with falls in the community group only.

Conclusion: Although TJA participants have a comparable number of falls to community dwelling older adults, they may possess more risk factors for falling and are more fearful of falling.

4.2 Background

Approximately one in three older adults fall at least once a year, with a third of falls leading to injury (Rubenstein, 2006). One risk factor for falling is osteoarthritis (OA) with up to 50% of ambulatory OA patients, recruited from a rheumatology outpatient clinic, reporting at least one fall per year (Brand, Aw, Lowe, & Morton, 2005; Lawlor, Patel, & Ebrahim, 2003). Patients with end-stage OA of the hip or knee, who may need a total joint arthroplasty (TJA) are exposed to several well-known falls risk factors during their perioperative period. Prior to surgery, TJA participants may have limited joint range of motion in the knees (Matsumoto et al., 2012; Tsonga et al., 2016), joint pain (Leveille et al., 2002; Leveille et al., 2009), lower extremity weakness (Ilfeld, Duke, & Donohue, 2010; Lawlor et al., 2003; Moreland, Richardson, Goldsmith, & Clase, 2004), balance deficits (S. Morrison, Colberg, Mariano, Parson, & Vinik, 2010), decreased quality of life (Trnvall, Marcusson, & Wressle, 2016), depressive symptomology (Briggs, Kennelly, & Kenny, 2017), and poor health status (Aarons, Hall, Hughes, & Salmon, 1996; Jones, Voaklander, Johnston, & Suarez-Almazor, 2000; Ritter, Albohm, Keating, Faris, & Meding, 1995). Post surgery, falls risk factors encountered by TJA participants include: use of NSAID pain medications (Hegeman et al., 2009), in-hospital falls immediately after surgery (Clarke, Timm, Goldberg, & Hattrup, 2012), and activity limitation (Gregg, Pereira, & Caspersen, 2000). Falls risk factors vary according to the population studied and TJA patients may have different relevant falls risk factors than independently living adults in the community. Although falls in older adults living in the community and in-hospital settings have been extensively examined, falls in TJA patients is an emerging area ofinterest.

Sparse evidence based on small clinical samples has reported falls prevalence in TJA patients, ranging from 22% to 63% (Matsumoto et al., 2012; Pozzi et al., 2015; Soison et al.,

2014; Tsonga et al., 2015). Few studies have explored risk factors in TJA patients in comparison to community dwelling controls. Research in TJA surgery has tended to focus on physical outcomes after surgery such as pain, (Ramirez, Goodman, Shah, & Jenkins, 2017), function (Fortin et al., 1999; Lingard, Katz, Wright, & Sledge, 2004), and range of motion (Aujla & Esler, 2017). Little attention has been paid to falls and a loss of confidence in their mobility and balance.

Studies of falls in TJA patients have shown that low balance confidence, measured by 12 activities of daily living, had a negative impact on activity and was associated with falls during recovery of TJA (β=-0.037, $p<0.01$) (Nagai, Ikutomo, Yamada, Tsuboyama, & Masuhara, 2014). Preliminary evidence suggests that falls self-efficacy, defined as a person's beliefs in one's ability to engage in certain activities of daily living without falling or losing balance, and fear of falling play an important role in the management of falls in TJA patients (Marques et al., 2016; Nguyen et al., 2014). Landers and colleagues (2016) found that fear of falling (measured by several scales) is higher in fallers than in non-fallers, and has been cited as an predictor of falls in independent older adults living in the community (β=-0.061, $p<0.01$). Several authors speculated that fear of falling results in falls in post-surgical participants because it discourages participation in exercise during recovery (Gagnon, Flint, Naglie, & Devins, 2005; Hadjistavropoulos et al., 2007; Howland et al., 1998).

The overall aim of this study was to examine falls, fear of falling, and documented falls risk factors in a cohort of TJA patients. The specific objectives are to examine a) reported falls and the fear of falling in TJA patients compared to community controls and to b) determine what established risk factors are associated with falls in the TJA cohort, and if these risk factors are different from those seen in the community controls. Due to the unclear association between TJA

and falls, it would be valuable to examine the differences between community controls and a TJA cohort.

4.3 Methods

A cross sectional survey was conducted in November 2016 to January 2017 with patients waiting for or recovering from TJA at the Edmonton Hip and Knee Clinic and older adults who attended two Flu Clinics in Edmonton, Alberta. The Edmonton Hip and Knee Clinic participants were recruited from a musculoskeletal clinic, which serves Edmonton and northern Alberta with in excess of 35 orthopaedic surgeons and multi-disciplinary teams. The two Flu Clinics were seasonal influenza immunization clinics, located in older neighbourhoods in Edmonton where it was anticipated a greater number of older adults would visit for influenza vaccines. Within this universal healthcare system, influenza vaccines were offered to all residents in the city. Survey inclusion criteria for TJA participants were (1) over the age of 60 years (2) waiting for or recovering from an either a total hip arthroplasty (THA) or total knee arthroplasty (TKA) and (3) English-speaking. Exclusion criteria were individuals who were dependant on wheelchair use for most mobility activities. Individuals at the Flu Clinics who have had previous a hip or knee replacement in the past 12 months were also excluded.

Patients at the Edmonton Hip and Knee Clinic were asked to complete the survey while they waited for their appointments. Those patients who were interested provided verbal consent prior to being given the survey to complete. A research assistant was available to answer questions or assist with reading or clarifying survey questions. Upon completion, participants returned the survey to the research assistant who quickly reviewed the survey to make certain all

questions were completed. A similar process was completed for people who attended the Edmonton Flu Clinic. Flu Clinic participants were similar in age and sex with participants from the Edmonton Hip and Knee Clinic after removing eight participants over the age of 85. Six additional participants were excluded from the analysis due to previous history of hip and knee replacement or due to presence of Muscular Sclerosis or Parkinson's disease.

The survey consisted of 50 questions (see Appendix C) and included demographics (8 questions), TJA surgery (5 questions), falls and circumstances of falls (10 questions), fear of falling (17 questions), established risked factor for falling, medical ("indicate all that apply" of out of 18 conditions), medications ("indicate all that apply" out of five drug categories, plus a "list other" option), physical activity and ambulatory (5 questions), and alcohol (3 questions). The survey questions were categorized with respect to: (1) general participant information, (2) falls information, (3) fear of falling, (4) medical information (5) physical activity and (6) behavioral risk factors. Survey development was based on previously validated scales of measurement for fear of falling, medical information, physical activity, and alcohol consumption (see Appendix E). Most questions were close-ended (multiple-choice or “indicate all that apply” options) to standardize responses and improve survey completion (Kitchenham & Pfleeger, 2002). Ethics approval was obtained through the University of Alberta Health Research Ethics Board (PRO 00065389).

Falls

A fall was defined as "a sudden loss of balance that leads you to land on the ground or a lower level than where you were originally" (Tinetti et al., 1988). Number of falls was

ascertained through participant self-report with the question, "in the past 12 months, did you have any falls?" and "if YES, how many falls have you had in the past 12 months?" Circumstances of the fall or falls such as where the fall occurred, related injuries, and seeking medical attention were also documented.

Fear of falling

Fear of falling was measured through the Activities-Specific Balance Confidence (ABC) scale (Powell & Myers, 1995). The ABC consists of 16-items that reports the participant's level of confidence regarding the possibility of falling when performing certain daily activities using a rating scale that ranges from 0%-100%. Individual item ratings are average to calculate a total balance confidence score. Overall scores can range from 0-100, with a score of 100 indicating complete confidence and a score of 0 indicative of no confidence. Thus, higher scores indicate greater balance confidence. Although no minimally clinically important difference (MCID) exist for ABC, Lajoie and colleagues (2004) found scores of <67% indicates a risk of falling can correctly identify fallers 84% of the time (sensitivity = 84%). Using a 4-point Likert scale of rating fear of falling ("not fearful", "a little fearful", "somewhat fearful", or "very fearful"), all participants rated their fear of falling (Howland et al., 1993).

Selection of factors associated with falls

Based on the literature (Deandrea et al., 2010; Rubenstein, 2006; Woolcott et al., 2009) potential correlates of falls in older adults with lower extremity arthritis were selected. A total of

21 modifiable falls risk factors were assessed and classified according to the Canadian Fall Prevention Curriculum © (see Appendix E).

Statistical Analysis

Descriptive data on falls and the fear of falling were completed according to the two groups: (1) TJA participants and (2) community dwelling controls. Prevalence of falls was the number of participants who reported at least one fall in the previous 12 months. A t-test was used to test the equality of the prevalence in both groups. Univariable logistic regression models (adjusting for sex and age) were performed to examine established risk factors associated with falls within the TJA cohort, and within the community controls. The dependant variable was fall status (yes/no in the previous 12 months). A *p*-value of 0.05 was considered statistically significant. Data were analyzed using STATA.

4.4 Results

Among the 198 participants of the TJA cohort recruited from the Edmonton Hip and Knee Clinic, the mean age was: 71.2 ± 6.6 years with 117 (59%) female. Almost half of the participants (n=88, 44%) reported having a previous TJA of either the hip (n=39, 20%) or knee joint (n=49, 24%) unrelated to the current TJA visit. 114 participants completed the survey who were attending the pre-operative education visit while 84 completed the survey while during their post-operative follow-up visit.

A total of 114 participants were recruited from the Edmonton Flu Clinics, with 14 participants excluded from the analysis due to previous TJA (6 participants) or age 85+ (8

participants) (Table 4-1). The mean age of the 100 participants who attended the flu clinics was 71.4 ± 5.70 years and 59% (n= 59) were female. Demographic characteristics including sex, age, body mass index, and education years were comparable between the TJA and community groups. Marital status was significantly different between the groups $\chi^2(2) = 17.8$, $p < 0.01$.

When examining risk factors for falls, significant differences were also seen with medications, activity and use of walking devices. TJA participants took more medications (mean: 1.8, SD: 1.4) than the community group (mean: 1.1, SD: 1.4) ($p<0.01$). In particular TJA participants also reported greater pain medication use and greater anti-depressant medication use than the community group. Activity level was not comparable between the two groups ($\chi^2(3) = 35.73$, $p < 0.01$).

Of the 100 participants in the community, 24 (24%) reported falling in the past year for a total of 37 fall events. Six were recurrent fallers (Table 4-2). Fifty percent (n=13) of falls occurred over six months ago, and 69% (n=18) occurred outside the home. Within the TJA group, 57 (29%) participants reported falling at least once over the past last year, of which 25 (13%) reported at least two falls (2 to 6 falls). Of the 114 participants attending the pre-operative education session, 34 reported at least one fall in the last year. In participants who came in for their 2 weeks, 6 weeks, 3 month, or 1-year post-operative visit (mean time: 114 ±132 days since surgery, median: 50 days since surgery), 11 of the 84 participants reported falling after their surgery (Supplemental table 5). The majority of TJA falls occurred outdoors (not at home) (Table 4-3). Regardless of the type of joint replaced, it did not have an effect on whether a person fell or not (see Appendix F, supplemental Table 1). The type of visit (pre-operative or post-operative visit) also did not have an effect on the fall status (see Appendix F, supplemental Table 2).

The correlations between the ABC and the 4-point Likert question, "How fearful are you of falling?" ($r=0.51$, $p>0.01$) indicated that the ABC is a good approximation for fear of falling. Although no statistically difference was seen between the number of fallers in the 2 groups ($p=0.38$), TJA participants had statistically significant lower ABC mean score, (67.0 ± 24.3), than the community controls (88.4 ± 14.9) ($p<0.01$) (Table 4-4). In the TJA group, ABC scores were also lower in 57 fallers (ABC=60.6 ± 23.9) as compared to 141 non-fallers (69.6 ± 24.1) ($p=0.02$). For community controls, the mean ABC for the 24 fallers was 83.2 ± 15.8, which showed a borderline significant trend of lower ABC scores than 76 non-fallers at 90.1 ± 14.9 ($p=0.05$). Forty-five percent (n=90) of the TJA participants scored below 67% on the ABC, which is indicative of being fearful of falling, as compared to 7% (n=7) in the community controls. In the TJA group, ABC did not differ between hip arthroplasty participants (n=88, 65.8 ± 24.0) and knee arthroplasty participants (n=110, 68.0 ± 24.4) ($p=0.53$) (Table 4-5).

Of the biologic and behavioural risk factors measured (Table 4-6), the TJA group had a higher mean individual number of risk factors for falling (6.3 ± 3.2) than the community control (3.7 ± 2.5) ($p<0.01$) (see Appendix F, supplemental Table 3). In the TJA group, the most commonly reported risk factors were presence having more than three chronic illnesses (n=117, 59%), and taking pain medication (n=114, 57%). In the community group, the most commonly reported risk factors were high blood pressure (n=44, 44%), having more than 3 chronic illnesses (n=40, 40%), and arthritis (n=23, 23%).

Risk factors associated with whether a person was a faller or not in both groups was having more than three comorbid conditions (TJA: OR: 2.2, 95% CI: 1.5, 6.5; community: OR:1.4, 95% CI: 1.1, 7.5). In the TJA group significant risk factors were: the use of more than four medications (OR:3 .8, 95% CI: 1.1, 13, $p=0.03$) compared to no medication, use of a walker

(OR:2.6, 95% CI: 1.2, 5.6, p=0.02) compared to no use of a walker, self-report "very afraid/somewhat afraid" as compared to "a bit afraid/not at all afraid" fear of falling (OR:2.3, 95% CI: 1.2, 4.6, p=0.01), higher fear of falling as measured by the continuous ABC scale (OR:0.98, 95% CI: 0.97, 0.99, p=0.02), self-reported chronic pain, (OR:2.1, 95% CI: 1.1, 2.9, p=0.03) and high blood pressure (OR:2.0, 95% CI: 1.1, 3.9, p=0.03) (Table 4-6).

Significant risk factors exclusive to the community dwelling adults included: mental health problems (OR: 7.9; 95% CI: 1.3, 50, p=0.03), use of antidepressants (OR: 5.9, 95% CI: 1.1, 31, p=0.04), urinary or bowl incontinence (OR: 5.1, 95% CI: 1.1, 22, p=0.03), use of a cane (OR: 7.6 (95% CI: 1.7, 35, p=0.02), and moderate to very active activity level (OR: 4.4, 95% CI: 1.6, 12.3, p<0.01) (Table 4-6).

4.5 Discussion

The findings from this survey are that the number of patients with TJA who reported falls over the past year was comparable to the falls reported in community older adults in spite of the TJA group reporting a greater number of individual risk factors and higher fear of falling than the community cohort. We also found that the type of joint was not a factor in falling. These rates of falling are similar to the number of falls reported in older adults in independently living community adults at 20 - 40% (Downton & Andrews, 1991; Talbot, Musiol, Witham, & Metter, 2005; Tinetti et al., 1988). Although it is reasonable to conclude TJA participants would have more falls than community dwelling older adults (Ilfeld et al., 2010) we did not find a significant difference between the two groups. This finding is congruent with earlier studies that reported no significant differences in rates of falls in TJA participants and hospital controls. In a

retrospective cohort study of 413 total knee arthroplasty participants, Riddle and colleagues (2016) found no clear or consistent pattern of increasing or decreasing rates of falls over the perioperative period using hospital data.

A greater number of participants with TJA were fearful of falling as compared to community controls. According to the results of several studies, up to 57% of independently living older adults aged 60 years or older feel some degree of fear for falling (Friedman, Munoz, West, Rubin, & Fried, 2002; Howland et al., 1998; Yardley & Smith, 2002). A major finding of this study is that fear of falling is significantly higher in the TJA groups as compared to community dwelling adults. This association was found in a prospective study that examined TJA participants, and compared fear of falling using the Falls Efficacy Scale International (FES-I) in knee OA patients (mean age: 67±7, 45% (16) female) to controls with no knee OA (mean age: 67±7, 53% (14) female) (Levinger et al., 2011). Both pre-operative patients and post-operative patients at four months after surgery were significantly more concerned about falling as compared to controls. Fear of falling is commonly regarded as "a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing" (Tinetti et al., 1988). Fear of falling may impede physical activity prior to surgery and functional recovery after TJA, potentially leading to more falls (Prusinowska, Komorowski, Przepióra, & Księżopolska-Orłowska, 2016).

Using two self-report measures for fear of falling: the ABC and the self-report question, "how fearful are you of falling", we found that fear of falling was significantly associated with falls in TJA patients, but not with the community group. This finding concurs with other studies in which fear of falling at baseline was correlated with falling at 20 months (OR:1.79; $p < 0005$). The absence of an association between fear of falling and falls, in our study, in the community

group could be due to the higher balance confidence (ABC=88.4 ± 14.9), compared with the normative data of community averages (ABC=79.8 ± 20.1) (Huang & Wang, 2009). Higher fall-related self-efficacy and confidence in performing certain daily tasks without losing balance has been associated with higher levels of activity function, performance, and fewer falls (Schepens, Sen, Painter, & Murphy, 2012).

One study identified walkers used to ambulate as a risk factor for falling (Grundstrom, Guse, & Layde, 2012). We found that use of walkers to ambulate was significant falls risk factor only for the TJA group. The relationship between use of walkers to ambulate and falls outcomes in TJA patients is one of interest. TJA patients are required to use walking devices such as walkers and canes during the recovery after TJA. The use of walkers, however, is a risk factor for falls after hospital discharge (Stevens, Thomas, Teh, & Greenspan, 2009). Walkers were associated with more falls and fall-related injuries (rate ratio=2.6 for walkers) in older adults over 65 treated in the emergency department for nonfatal fall injuries. Education materials on the proper use of walkers and how walkers affect falls risk during the preoperative to postoperative period have yet to be addressed.

We also found that a greater number of comorbid conditions was a significant factor associated with whether a person fell or not. Our result corroborates with other reports that post-operative total hip arthroplasty (THA) non-fallers were significantly more likely to have less than one comorbid condition as compared to THA fallers (Ikutomo et al., 2015; Rubenstein, 2006).

Different comorbidities were associated with falls in the two groups. In TJA patients, high blood pressure, self-reported chronic pain, self-reported eye-problems, and use of more than four medications, and use of a cane were associated with fall status. Although a similar

proportion of hypertension was seen in all groups, high blood pressure was correlated with fall status in the TJA group. Hypertension has conflicting data in the literature, several studies suggest that standing systolic blood pressure of less than 110mmHg and dizziness upon standing (OR: 2.1, 95% CI:1.2, 3.7) is associated with falls (Campbell, Borrie, & Spears, 1989; Graafmans et al., 1996) while others have found no associations between blood pressure and falls (Chu et al., 2005).

Our survey found pain was significantly associated with falls in the TJA group but not the community participants. Pain has been a well-established risk factor for falls in the literature. In a prospective study of 749 community dwelling adults over the age of 70 years, risk for falls was increased significantly if participants reported having 2 or more pain sites, after adjusting for age and comorbid conditions (RR:1.53; 95% CI: 1.17, 1.99) (Leveille et al., 2009). Other authors also observed an association between falls and poor vision among community dwelling, ambulatory adults (Chu et al., 2005) these associations are however not found in the TJA group and community group of our study and other studies with similar populations (Bruce, Hunter, Peters, Davis, & Davis, 2015).

Increasing age leads to the likelihood of developing several chronic conditions, which leads to treatment with multiple medications. Number of medications was not associated with falls in the TJA group but not the community group; we believe this is due to differences in the detection and classification of medications between community and TJA participants. All participants were asked to indicate on a survey whether they are currently taking "antipsychotics", "sedatives/hypnotics", "pain medications", "anti-depressants", or "none". In our study, most TJA patients reviewed their medications with a nurse as part of their visit to the clinic prior to taking the survey. It is possible that some control participants are unaware of drug

classifications, making potential underreporting or over-reporting of certain medications a potential bias and skewing medication related results in the control group. This is likely, considering link between medications and falls in the TJA group of our study, and the strong reports of the association between falls and psychotropics (RR: 1.35, 95% CI: 1.22, 1.48), sedatives/hypnotics (RR: 1.12 0.99-1.26), and anti-depressants (RR: 1.27, 95% CI: 1.12, 1.44) in other studies of community dwelling adults (Leipzig, Cumming, & Tinetti, 1999).

Participants in the TJA group had a higher number of individual risk factors. Falls may result from an accumulation of several risk factors (Tinetti, Williams, & Mayewski, 1986; Tinetti et al., 1988). In an early study of risk factors for falls, Tinetti and colleagues (1986) found that the proportion of community dwelling older adults, fallers increased from 0% to 31% in those with less than three risk factors to those with four to six risk factors. Robbins and colleagues (1989) developed a falls prediction model (sensitivity= 89%; specificity=60%) with 217 participants and found that the predicted 1-year falls risk was 12% for individuals with none of the risk factors measured in their study, and up to 100% for individuals with all the risk factors measured in the study.

Our survey presents various limitations. Firstly, the cross-sectional study design did not allow us to identify patient characteristics that are associated with an increased risk of falling, and causal mechanism. The sample of our study was a convenience sample of individuals who agreed to participate in the study, which may not be representative of all TJA adults. Participants, however, were recruited from a regional site with more than 35 orthopaedic surgeons rather than a single surgeon or hospital. A second limitation is our method for ascertaining falls. Our recall time was a period of 1-year, which has been shown to under-report falls, especially if a memorable injury did not result from the fall (Ganz et al., 2005).

In conclusion, findings from this survey suggest that the proportion of fallers is comparable between TJA participants and community dwelling older adults; however, recurrent fallers are greater in TJA participants. Overall, TJA participants have a greater number of individual risk factors for falling and are more fearful of falling than community dwelling adults. If specific modifiable risk factors can be identified such as use of walker, clinicians can use evidence-based falls risk factors to assess the potential of sustaining a fall in total joint arthroplasty patients. A falls prevention strategy that is tailored to the falls risk factors of TJA patients is warranted.

Table 4-1 Demographic, medical, ambulatory, and behavioural profiles between total joint arthroplasty and community participants

	Total Joint Arthroplasty n=198	**Community** n=100	***p-value***
THA, n (%)	88 (44%)	N/A	-
TKA, n (%)	110 (56%)	N/A	-
Other joint involvement, n (%)	88 (44%),	0	-
Previous hip replacement, n (%)	39 (20%)	N/A	-
Previous knee replacement, n (%)	49 (24%)	N/A	-
Demographic			
Age, years, mean (SD)	71.2 (6.6)	71.4 (5.7)	0.79*
Sex, female, n (%)	117 (59%)	59 (59%)	0.98†
Marital status, n (%)			**<0.01**†
Married/Common Law	151 (76%)	64 (64%)	
Divorced/Widowed	46 (23%)	26 (26%)	
Never Married/Single	1 (0.5%)	10 (10%)	
Employment, n (%)			0.33†
Retired	152 (76%)	87 (87%)	
Unemployed	8 (4%)	3 (3%)	
Disability Leave	4 (9%)	1 (1%)	
Part Time/Casual	9 (4%)	2 (2%)	
Full Time	25 (12%)	7 (7%)	
Education years, mean (SD)	13.4 (8.4)	14.0 (3.1)	0.37*
Body mass index, kg/m^2 (SD)	30.5 (5.7)	27.4 (5.2)	**<0.01***
Medical			
Comorbid conditions, mean (SD)	3.1 (2.0)	2.3 (1.8)	**<0.01***
No conditions, n (%)	18 (9%)	15 (15%)	-
0-3 Conditions	81 (41%)	60 (60%)	-

3+ Conditions	117 (59%)	40 (40%)	-
High blood pressure, n (%)	99 (50%)	44 (44%)	0.32†
Arthritis, n (%)	120 (61%)	34 (34%)	**<0.01**†
Eye problems, n (%)	41 (21%)	24 (24%)	0.52†
Self-report chronic pain, n (%)	66 (33%)	23 (23%)	0.07†
Serious joint/bone problems, n (%)	47 (23%)	5 (5%)	**<0.01**†
Osteoporosis, n (%)	50 (25%)	18 (18%)	0.17†
Circulatory problems, n (%)	17 (9%)	6 (6%)	0.44†
Diabetes, n (%)	44 (22%)	13 (13%)	0.06†
Stroke or paralysis/speech problems due to stroke, n (%)	6 (3%)	2 (2%)	0.61†
Heart disease, n (%)	15 (8%)	13 (13%)	0.12†
Asthma, n (%)	24 (12%)	13 (13%)	0.80†
Trouble hearing/deafness, n (%)	42 (21%)	21 (21%)	1.00†
Renal disease, n (%)	1 (1%)	2 (2%)	0.22†
Urinary or bowel incontinence, n (%)	25 (12%)	9 (9%)	0.44†
Mental health problems, n (%)	15 (7.5%)	6 (6%)	0.63†
Medications			
Number of medications, mean (SD)	1.8 (1.4)	1.1 (1.4)	**<0.01***
Number of medications, categorical			**0.03**†
None, n (%)	37 (19%)	31 (31%)	-
1-3	137 (69%)	63 (63%)	-
4+	24 (12%)	6 (6%)	-
Pain, n (%)	114 (57%)	17 (17%)	**<0.01**†
Blood Pressure, n (%)	25 (13%)	12 (12%)	0.80†
Anti-Depressants, n (%)	32 (16%)	7 (7%)	**0.02**†
Anti-Psychotics, n (%)	2 (1%)	0	0.31†
Sedatives or Hypnotics, n (%)	10 (5%)	2 (2%)	0.2†

Anxiety Medication, n (%)	10 (5%)	1 (1%)	0.08†
Self- report general health, n (%)			0.21†
Excellent	22 (11%)	17 (17%)	
Very Good	67 (33%)	42 (42%)	
Good	81 (41%)	32 (32%)	
Fair	27 (14%)	9 (9%)	
Poor	1 (1%)	0 (0%)	
Ambulatory			
Walking Devices, n (%)			**<0.01**††
None	67 (34%)	11 (11%)	-
Uses a canes	101 (51%)	9 (9%)	-
Uses one or more crutches	21 (10%)	0	-
Walker	41 (21%)	2 (2%)	-
Walk distance, n (%)			**<0.01**†
Unlimited	24 (12%)	66 (66%)	
6-10 blocks	19 (9%)	15 (15%)	
1-5 blocks	66 (33%)	14 (14%)	
Less than 1 block	52 (26%)	3 (3%)	
Indoors only	36 (18%)	2 (2%)	
Limits to walking			**<0.01**††
Pain, n (%)	146 (74%)	21 (21%)	
Fatigue, n (%)	45 (22%)	25 (25%)	
No Limits, n (%)	18 (9%)	54 (54%)	
Flights of stairs able to climb, mean (SD)	1.6 (2.1)	3.7 (3.1)	**<0.01***
Flights of stairs able to climb, categorical			**<0.01**
Unable to do stairs/<1 flight	140	3	-
More than 1 flight of stairs	58	97	-
Behavioural			

Activity Level *("Would you consider yourself to be"), n (%)*			**<0.01†**
Very Active	9 (4%)	21 (21%)	
Moderately Active	84 (42%)	56 (56%)	
A Bit Active	68 (34%)	19 (19%)	
Not at all Active	36 (18%)	4 (4%)	
Alcohol consumption, n (%)			0.17†
Does not drink	100 (51%)	43 (43%)	
Once a month	32 (16%)	25 (25%)	
Once a week	66 (33%)	32 (32%)	
Fear of Falling	198	100	
ABC mean score (SD)	67.0 (24.3)	88.4 (14.9)	<0.01*
Fear of falling (4-point Likert scale)			**<0.01†**
Not afraid (not at all afraid/a bit)	121 (61%)	17 (17%)	-
Afraid (very afraid/somewhat afraid)	77 (39%)	83 (83%)	-

*Student's t-test
† Chi-square test
††Cochran's Q test for non-independent categorical variables

Table 4-2 Falls and circumstances of falls in total joint arthroplasty participants, and community controls

	Total Joint Arthroplasty (n=198)	**Community** (n=100)
Number of fallers	57 (29%)	24 (24%)
Recurrent fallers (2 or more)	25 (13%)	6 (6%)
Numbers of non-fallers	141 (71%)	76 (76%)
Total number of falls	96	37
When did the fall happen?, n (%)		
<1 months	5 (7%)	5 (19%)
1-3 months	20 (29%)	0
3-6 months	32 (11%)	8 (31%)
6+ months	22 (29%)	13 (50%)
Location of falls, n (%)		
At home - indoors	26 (37%)	5 (19%)
At home - outdoors	12 (17%)	3 (12%)
Outdoors	30 (43%)	18 (69%)
Hospital	1 (1%)	0
Fall-related injuries:		
Sprain/strain/bruises cuts	28	8
Head injuries	3	1
Fracture	4	1
Did you seek medical attention from a health professional within 48 hours? (Yes), n (%)	18 (18%)	3 (8)%

Table 4-3 Falls and circumstances of falls in pre-operative participants, post operative participants, and community controls

	Pre-operative TJA (n=114)	**Post-operative TJA** (n=84)	**Community** (n=100)
Number of fallers (having at least one fall)	34 (30%)	23 (27%)	24 (24%)
Numbers of non-fallers	80 (70%)	61 (73%)	6 (6%)
Total number of falls	52	44	37
When did the fall happen?			
<1 months	3 (7%)	2 (8%)	5 (19%)
1-3 months	15 (35%)	5 (19%)	0
3-6 months	11 (26%)	11 (42%)	8 (31%)
6+ months	14 (32%)	8 (31%)	13 (50%)
Location of falls, n (%)			
At home - indoors	14 (34%)	2 (8%)	5 (19%)
At home - outdoors	9 (21%)	5 (19%)	3 (12%)
Outdoors	18 (43%)	11 (42%)	18 (69%)
Hospital	0	8 (31%)	0
Fall-related injuries:			
Sprain/strain/bruises cuts	18	10	8
Head injuries	2	1	1
Fracture	1	3	1
Did you seek medical attention from a health professional within 48 hours? (Yes)	11	8	

Table 4-4 Balance confidence in total joint arthroplasty (TJA) and community participants

	TJA (n=198)		**Community** (n=100)	
Activities-Specific Balance Scale (ABC), mean (SD)	67.0 (24.3)*		88.4 (14.9)	
	Fallers (n= 57)	**Non-fallers** (n=141)	**Fallers** (n= 24)	**Non-fallers** (n= 76)
Fear of falling, ABC, mean (SD)	60.6 (23.9)**	69.6 (24.1)	83.2 (15.8)**	90.1 (14.9)
Self-reported fear of falling, *n (%)*	*Are you afraid of falling?*			
Not at all afraid	5 (8%)	31 (22%)	4 (16%)	30 (39%)
Slightly afraid"	21 (36%)	64 (45%)	15 (63%)	34 (45%)
Somewhat afraid	17 (29%)	29 (20%)	4 (16%)	9 (12%)
Very afraid	14 (24%)	17 (12%)	1 (4%)	3 (4%)

*Mean ABC is significantly different between TJA group and community group as determined by student's t-test for unequal variances ($p< 0.01$)

**Mean ABC is significantly different between fallers and non-fallers in TJA group ($p<0.01$) but not significantly different between fallers and non-fallers in community group as determined by student's t-test of equal variances ($p=0.34$)

Table 4-5 Mean Activities-specific Balance Confidence scale in pre-operational participants, post-operational participants, and community dwelling controls

	Pre-Operative (n=114)	**Post-Operative** (n=84)	**Community** (n=100)	**p-value†**	**Total hip Arthroplasty** (n=88)	**Total knee arthroplasty** (n=110)	**p-value***
Activities-Specific Balance Scale (ABC), mean (SD)	66.1 (23.8)	68.4 (25.3)	88.4 (14.9)	0.002	65.8 (24.0)	68.0 (24.4)	0.53

* Student's t-test of equal variance

† There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2.29)=6.13$, $p=0.002$). A Tukey post-hoc test revealed that ABC scores were statistically significantly lower in the pre-operative group ($p<0.01$) and post-operative group ($p>0.01$) as compared to the community group. There was no statistically significant difference between the pre-operative group and post-operative group.

Table 4-6 Factors associated with falls within total joint arthroplasty group, and within community participants group using Logistic Regression after adjusting for age and sex

Risk Factor	n	Total Joint Arthroplasty **OR (95% CI, *p*)**	n	Community **OR (95% CI, *p*)**
Number of comorbid conditions				
0-3	81	1.0 (Reference)	60	1.0 (Reference)
3+	117	**2.2 (1.5-6.5, <0.01)**	**40**	**1.4 (1.1-7.5, 0.03)**
Self-report chronic pain	66	**2.1 (1.1-2.9, 0.03)**	23	1.5 (0.5-4.3, 0.42)
Stroke	6	2.2 (0.4-11, 0.36)	2	N/A
Osteoporosis	50	1.9 (1.0-3.9, 0.07)	18	1.8 (0.6-5.6, 0.30)
Arthritis	120	1.5 (0.8-3.03, 0.19)	34	1.9 (0.7-4.9, 0.17)
High blood pressure	99	**2.0 (1.1-3.9, 0.03)**	44	1.1 (0.4-3.1; 0.76)
Eye problems	41	1.3 (0.6-2.9, 0.47)	24	1.4 (0.5-4.2, 0.46)
Trouble hearing/deafness	42	1.2 (0.6-2.7, 0.59)	21	1.5 (0.5-4.5, 0.50)
Urinary or bowl incontinence	25	1.4 (0.6-3.7, 0.42)	9	**5.1 (1.1-22, 0.03)**
Mental health problems	15	2.1 (0.7-6.2, 0.17)	6	**8.0 (1.3-50, 0.03)**
Fear of Falling				
Not afraid of falling (not at all afraid/ a bit)	121	1.0 (Reference)	17	1.0 (Reference)
Afraid of falling (very afraid/somewhat afraid)	77	**2.3 (1.2-4.6, 0.01)**	83	1.1 (0.4-4.8, 0.58)
ABC (continuous)	198	**0.98 (0.97-0.99, 0.02)**	100	0.97 (0.9-1.0, 0.06)
Medications				
None	37	1.0 (Reference)	45	1.0 (Reference)
1-3	137	2.1 (0.8-5.6, 0.19)	63	2.1 (0.8-5.5, 0.10)
4+	24	**3.8 (1.1-13, 0.03)**	6	3.4 (0.5-24, 0.20)
Use of anti-psychotics	2	N/A	0	N/A

Use of pain medication	114	1.5 (0.8-2.9, 0.18)	18	1.1 (0.5-4.4, 0.50)
Use of sedatives/hypnotics	10	1.7 (0.5-6.5, 0.41)	2	N/A
Use of anti-depressants	32	1.8 (0.9-4.2, 0.11)	7	**5.9 (1.1-32, 0.04)**
Activity Level				
Not active/a bit active	93	1.0 (Reference)	23	1.0 (Reference)
Moderately active/very active	105	1.3 (0.7-2.4, 0.39)	77	**4.4 (1.6-12, <0.01)**
Flights of stairs able to climb				
Unable to do stairs /<1 flight	140	1.0 (Reference)	3	N/A
More than 1 flight of stairs	58	1.6 (0.8-3.1, 0.19)	97	N/A
Walk distance				
Unable to Walk/1-5 Blocks	109	1.0 (Reference)	19	1.0 (Reference)
More than 6 Blocks	43	1.2 (0.6-2.2, 0.62)	81	2.2 (0.7-6.7, 0.14)
Walking devices				
Does not use a cane	97	1.0 (Reference)	81	1.0 (Reference)
Cane	101	1.0 (0.50-1.8, 0.89)	9	**7.6 (1.7-35, 0.02)**
Does not use crutch(es)	177	1.0 (Reference)	100	1.0 (Reference)
Crutch	21	1.0 (0.4-2.7, 0.13)	0	N/A
Does not use a walker	157	1.0 (Reference)	98	1.0 (Reference)
Walker use	41	**2.6 (1.2-5.6, 0.02)**	2	N/A
Alcohol consumption (yes)	98	1.1 (0.6-2.3, 0.70)	57	1.4 (0.4-4.3, 0.59)

N/A = Not appropriate

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Chapter 5: Discussion

The overall aim of this thesis is to examine the prevalence of falls in TJA patients, and to understand how fear of falling and other factors explain falls in total joint arthroplasty (TJA) patients. To address this overall aim, two papers were written; the first dealing with a scoping review on evidence documenting falls in TJA populations and the associated falls risk factors. The research gaps identified in the scoping review provided direction for a cross-sectional survey of TJA patients and a control group of community dwelling older adults to examine the number of fallers, the proportion of falls reported by patients with TJA, and falls risk factors.

5.1. Scoping Review

Before examining risk factors for falling in patients with TJA, a scoping review that examined twelve papers on falls in TJA participants was conducted. Falls and falls risk factors in TJA patients is an emerging topic of interest, with a majority of papers published in the previous five years (Hill et al., 2016; Ikutomo et al., 2015; Levinger et al., 2011; Matsumoto et al., 2012; Pozzi et al., 2015; Riddle & Golladay, 2016; Smith et al., 2016; Soison et al., 2014; Tsonga et al., 2015; Tsonga et al., 2016). Swinkles and colleagues (2008) published the first paper examining falls in a prospective total knee arthroplasty (TKA) population (n=99), and found older adults (mean age: 73.4±4.9; 64% female) reported more falls waiting for TKA surgery than at three months after the operation. Ten of the twelve articles examining falls with TKA and/or total hip arthroplasty (THA) participants were published since 2008. Five were small clinical studies consisting of less than 75 participants (Matsumoto et al., 2012; Pozzi et al., 2015; Soison et al., 2014; Tsonga et al., 2015; Tsonga et al., 2016). Three of the twelve studies were multi-

center, retrospective cohort studies with large sample sizes (>282) (Hill et al., 2016; Riddle & Golladay, 2016; Smith et al., 2016). The scoping review was intended to broadly map existing literature on THA and/or TKA, and we found the quality of the studies on this topic were generally needing improvement with regards to methodology. The SIGN Guidelines Checklist 3: Cohort Studies (Scottish Intercollegiate Guidelines Network, 2014) was used to assess individual studies. We determined four studies were poor quality (Ikutomo et al., 2015; Mitchell et al., 2007; Pozzi et al., 2015; Soison et al., 2014). Two of eleven articles were "high" quality, prospective studies (Matsumoto et al., 2012; Swinkels et al., 2008) with appropriate statistical power to demonstrate evidence of an association between falls and the falls risk factors under investigation. The remaining studies were of "acceptable" quality. Because of the heterogeneity of the articles, pooling was not possible. However, based on the currently published studies, a few patterns are emerging.

(1) Pre-operative TKA participants report more falls than post-operative TKA participants

This conclusion is tentatively drawn from patterns seen in two prospective studies of TKA that were of "high"(Swinkels et al., 2008) and "acceptable" (Tsonga et al., 2016) quality, comparing pre-operative TKA participants to post-operative TKA patients. Swinkles and colleagues interviewed participants at three months prior to surgery and found that 32% (n=24/75) of TKA participants reported at least one fall in the past month. Tsonga and colleagues (2016) interviewed pre-operative TKA participants at 2 weeks prior to surgery and found 63% (n=43/68) reported at least one fall in the past month. After surgery, the post-operative monthly falls rates were lower at 13% (n=11/83) measured at one month post-surgery (Swinkels et al.,

2008) and 22% (n=15/68) measured at one month post-surgery (Tsonga et al., 2016). Comparing prevalence of falls between studies is challenging because unlike other health conditions that can be summarized through point prevalence (i.e. the proportion of a population with a "condition" at a specific point in time), prevalence of falls can only be reported in relation to time as (1) the number of participants sustaining a fall over a period of time (e.g. individual/time) (2) the number of falls over a period of time (e.g. falls/time) or (3) the falls rate (e.g. falls/per person/[time denominator variable]).

Studies often use different time periods (e.g. 1 week, 1 month, 3 months, 1 year), making direct prevalence comparisons between studies challenging. Recall bias due to different recall periods can also contribute to a substantial source of variation in reported fall rates. Interview survey was the most often used method for investigating falls in the scoping review with TJA participants. It is possible that in the eight studies with retrospective recall of more than three months (Hill et al., 2016; Ikutomo et al., 2015; Levinger et al., 2011; Pozzi et al., 2015; Riddle & Golladay, 2016; Smith et al., 2016; Soison et al., 2014; Tsonga et al., 2015), misclassification of outcomes (i.e. falls) may have resulted in an underestimation of falls events, especially if falls events did not result in injuries (Ziere et al., 2006). There is no reason to believe that the misclassification of outcomes in the studies included in the scoping review was differential, due to the fact that several studies excluded participants with an established cognitive disorder (i.e. dementia) (Ikutomo et al., 2015).

(2) TJA participants are fearful of falling prior to surgery and post surgery

It is well established that 24% to 55% of older adults living in the community are fearful of falling (Chang, Chen, & Chou, 2017; Howland et al., 1998; S. L. Murphy, Williams, & Gill,

2002). Five studies in the scoping review measured fear of falling with the following instruments: Falls Efficacy Scale (FES), Falls Efficacy Scale International (FES-I), and the Activities-specific Balance Scale (ABC). The FES-I and ABC has high internal consistency (Cronbach's Alpha =0.91 and 0.92, respectively) and the FES-I and ABC also has "excellent" concurrent validity (correlation coefficient: -0.84), indicating the measure used to assess fear of falling should not affect the interpretation of the results. Studies in pre-operational total knee arthroplasty (TKA) participants found fallers were more fearful than non-fallers (p=0.005) (Hill et al., 2016; Tsonga et al., 2016). Of the five studies examining fear of falling, only one study found fear of falling to be predictive of falls (Tsonga et al., 2016). Since most studies in the scoping review that measured fear of falling did not address or control for activity limitation (Hill et al., 2016; Levinger et al., 2011; Tsonga et al., 2015; Tsonga et al., 2016), which many authors believe has a causal association with falls (Allison et al., 2013; Painter et al., 2012), it is not possible to determine whether low-falls efficacy lead to reduced activity and functioning.

The current literature on falls in TJA participants is inconclusive about the remaining risk factors. Since methodological quality did not rule out any studies in our scoping review, generalizable results or comparable results are difficult to justify, specifically with regards to medications and comorbid conditions. Another consideration in TJA participants that has not been sufficiently addressed in the current literature is falls differences between THA participants as compared to TKA participants. More studies in the scoping review focused on TKA participants, whereas only two articles examined THA participants. Since there are differences THA and TKA participants in terms of age and functional recovery (Bourne, Chesworth, Davis, Mahomed, & Charron, 2010; Brien, Bennett, Doran, & Beverland, 2009), both THA and TKA participants were included in our survey.

5.2. Association Between Falls and Risk Factors for Falling in TJA Participants: Conclusions from the Cross-sectional Survey

Based on the findings and limitations of the scoping review, a cross sectional survey was completed to examine the prevalence of falls, fear of falling, and falls risk factors, and how these compare to a community dwelling adult group (control). In our survey, we had a total of 298 participants, 198 TJA participants, and 100 community dwelling controls. There were 114 TJA participants in the pre-operative group, who were scheduled for TJA in three months, and 84 in the post-operative group, who were returning for their 2 weeks, 6 weeks, 3 months, or 1-year follow up. The population was compared with 100 community controls, which provided novel insights into falls and falls risk factors in the TJA population, because currently, there is only one other study in the literature examines TJA participants as compared to healthy community controls (Levinger et al., 2011).

(1) Prevalence of falls: What the cross-sectional survey revealed about falls in TJA participants

Our survey found that pre-operational participants reported more falls than post-operational participants, regardless of type of joint being replaced. Out of the 114 pre-operational participants, 34% (n=34) fell in the last year. Of that cohort, 52% (n=60) were scheduled for TKA and 47% (n=54) THA (see Appendix F, supplemental table 4). Out of the 84 post-operational participants, 11(18%) had a post-operative fall (see Appendix F, supplemental table 5), while 27% (n=23) reported falling at least once within the last year. In the post-operational cohort, 50 (59%) were recovering from a TKA and 34 (41%) were recovering from a THA.

The pre-operative prevalence rates of our survey are comparable, though slightly lower, than rates reported in the scoping review of the thesis, which found the 1-year reported falls in patients who were waiting for TJA ranged from 8% to 63.2% (Hill et al., 2016; Levinger et al., 2011; Riddle & Golladay, 2016; Tsonga et al., 2015). The majority of studies reported prevalence rates of >40% in THA or TKA patients. Specifically, Tsonga et al (2015) and Levinger et al (2011) examined TKA participants and reported a pre-operative prevalence of 63.2% of falls in the last year, measured at approximately 1 month prior to surgery. Hill et al (2016) examined both THA (n=85) and TKA (n=197) participants and reported a prevalence of 41% in the last year at 2-4 weeks prior to surgery. The remainder study that reported the lowest pre-operative prevalence of 8% (Riddle & Golladay, 2016) was retrospective in nature of TKA patients. The authors of the study surmised that the low pre-operative rate of falls may be due to inaccurate classification of pre-operative falls as post-operative falls, due to the time-varying nature of total joint arthroplasty in their study, and this likely caused a biased report of falls prevalence rates. A one-year follow up study in agreement with our survey and scoping review findings concluded that pre-operational TKA participants reported a falls prevalence over three months to be 24.2%, twice as high as the falls prevalence of 12% in the same patients at 3 months post-operationally (Swinkels et al., 2008). Looking at the pattern of several independent studies, we conclude that pre-operational participants report more falls than TJA participants after surgery. This could be due to the fact that factors such as pain, function, quality of life, and fear of falling improve after TJA surgery, supressing the factors that have a strong association with falls.

Previous research showed differences in balance outcomes between THA and TKA participants (Bachmeier et al., 2001). Due to differences in THA and TKA outcomes, it may be

reasonable to conclude that falls rates may differ between the two groups. However, our cross-sectional survey revealed no difference between THA and TKA falls prevalence. This conclusions is in line with the findings from the scoping review, where two studies of "low" quality (Mitchell et al., 2007) and "acceptable" quality (Smith et al., 2016) found that the joint being replaced is not associated with falls (Mitchell et al., 2007; Smith et al., 2016). Fall status was not significantly associated with the type of joint being replaced (THA or TKA) in a cross sectional study (n=199) (Mitchell et al., 2007). And a previous history of hip OA was not associated with falls in TKA participants (OR: 1.6, 95% CI: 0.64-4.08) (Smith et al., 2016). Our study also did not observe any significant correlation between the joint that was replace and fall status (see Appendix F, supplemental Table 2). However, this is a tentative conclusion since 44% (n=88) of our TJA participants recruited from the Edmonton Hip and Knee Clinic have had either a previous knee replacement or previous hip replacement, specifically, 39 (20%) had a previous THA and 29 (25%) had a previous TKA.

The findings from this survey showed that TJA participants reported similar fall rates compared to community adults. This result reflects what one other study (Levinger et al., 2011) that compared TKA participants to community participants with no clinical diagnosis of OA, rheumatoid arthritis, or history of knee trauma or pain. We found the 1-year fall prevalence was 29% (n=57) in the TJA group and 24% (n=24) in the controls. Levinger and colleagues (2011) found that in a smaller clinical sample, 48% TKA patients fell (n=35) compared to 30% in the control group (n=27). Since the study systematically excluded older adults in the community who had arthritis and pain, known risk factors for falls in community dwelling older adults, it was not a complete representation of all community dwelling adults. Our survey examined a community dwelling community that was representative of all community dwelling older adults.

The current data on falls prevalence in TJA patients is sparse and varied. Based on the current literature and the results of our survey, we tentatively conclude that participants waiting for TJA report more falls than participants recovering from TJA, that the joint being replaced does not influence falls rates, and that TJA older adults are not more likely to fall as compared to older adults living in the community,

(2) Fear of falling in TJA participants is associated with falls

The findings from our survey reported more fear of falling with the TJA cohort as compared to community adults, and that fear of falling was significantly associated with falls in the TJA cohort. Levinger and colleagues (2011)reported similar findings in TKA participants waiting for surgery using the Falls-Efficacy-Scale. Thirty-five TKA patients reported a higher fear of falling (FES=11.4, SD: 3.0) as compared to twenty-seven community dwelling seniors (FES=9.7, SD: 2.9) ($p<0.05$) with comparable 12-month fall rates in the TJA and control groups. While no minimal clinically important difference (MCID) exists for the Activities-Specific Balance Scale, we found that Activities-Specific Balance Scale scores approximately reflect four levels of fear ("not fearful", "a little fearful", "somewhat fearful", and "very fearful") regardless of the grouping (i.e. community, TJA cohort, THA, or TKA) (see Appendix F, supplemental table 6).

Although fear of falling is higher in TJA participants, in particular, the pre-operative groups, reducing fear of falling may not lead to better falls outcomes since we cannot infer a causal mechanism between fear of falling and fall events. Some authors believe that fear of falling leads to inactivity, which, in turn causes falls. However, when fear of falling does not lead to activity limitation, fear of falling, may not cause (Allison et al., 2013; Painter et al., 2012).

Whether fear of falling leads to less activity in TJA participants is not addressed by our survey or in the studies of our scoping review. More research needs to be carried out on the association between fear of falling, activity restriction, and falls in TJA participants prior to and post TJA.

(3) Risk factors associated with falls – similarities and differences between TJA participants and community controls

The survey also addressed modifiable, intrinsic risk factors classified as: biological and behavioural (Table 4-6). TJA group had higher number of individual risk factors, defined as the number of risk factors an individual possessed measured in this study (Appendix F, supplemental Table 3) (mean: 6.3±3.2) as compared to community group (mean: 3.73 ±2.54). TJA and community participants one risk factors correlated with falls: having more than three comorbid conditions (Table 4-6).

Two risk factors that correlate with falls in TJA participants but not community participants were: (1) use of a walker (2) high blood pressure (Table 4-6). Self-reported use of a walker to ambulate (walker use) compared to self-report of no walker use was a risk factor for falls in the TJA sample, and significantly associated with a fall event (Table 4-6). Only one other paper examines use of supports and falls in TJA participants and their result conflicts with the findings of our survey. Specifically, Ikutomoto and colleagues (2015) found that non-fallers were associated with walking aids ($p=0.044$) in older THA females (95% of sample) (mean age = 66±8.7). One explanation that could account for our difference is that Ikutomoto and colleagues (2015) examined a hip arthroplasty population, which may not be comparable to a cohort comprising both THA participants and TKA participants. THA participants often have greater improvements in pain relief and physical function scores as compared to knee arthroplasty participants. Type of walking aids used before and after TJA may also differ between THA and

TKA participants (Jones et al., 2000; Rissanen, Aro, Slätis, Sintonen, & Paavolainen, 1995; Salmon, Hall, Peerbhoy, Shenkin, & Parker, 2001).

To our knowledge, no other studies have examined high blood pressure as a possible risk factor in TJA participants. We found that high blood pressure in TJA participants was associated with falls (OR: 2.0; 95% CI: 1.09-3.9). In community dwelling older adults, two studies have indicated an association between blood pressure and falls in older adults (Kario et al., 2001; Klein et al., 2013). In the past, more studies have focused on hypotension, however having hypertension has been associated with orthostatic hypotension and falls (Goldstein, Pechnik, Holmes, Eldadah, & Sharabi, 2003). Orthostatic hypotension is low blood pressure in individuals when rising from a lying position; it often results in dizziness, light-headedness, or fainting (Ooi, Hossain, & Lipsitz, 2000). The physiological relationship blood pressure and falls is unclear in the literature, however, there is evidence that suggest that hypertension that is not controlled by medications may be correlated with more falls (Gangavati et al., 2011; Shen, He, Chu, He, & Chen, 2015).

Our survey reported injury rates and fall rates comparable to the national average. We found that 35 (36%) of TJA participants reported that the falls lead to injury, and that the majority of the injuries were minor including bruises, cuts, sprains, or strains. Three (3%) of reported injuries were head injuries and 4 (4%) were fractures. Similar results were found in our control group, where 27% (n=27) of participants reported injuries. These rates are comparable to injury rates reported in older adults between the ages of 65 and 85 living in the community, where 31%-39% of falls lead to injuries (Stevens, Corso, Finkelstein, & Miller, 2006). These results indicate that injury patterns and rates do not differ between those with OA waiting for or recovering from surgery and community dwelling older adults without OA.

In-hospital falls is of interest in the TJA population because of the length of stay. TJA patients remain hospitalized for approximately 4 days (IQR: 4; median 4) for hip replacements and 3 days (IQR: 2; median 3) for knee replacements (Canadian Institute for Health Information, 2015). During this time, patients are at high risk for falling because of the surgery, medications, and post-operative pain. A systematic review of in-hospital falls found that in-hospital falls were related to gait instability, and lower limb weakness, which are factors that are significantly correlated with falls (Oliver et al., 2004). Gait instability and weakness are specific factors reported with TJA patients. We found two of the eight participants who returned for their two-week follow up visit reported a fall since their date of surgery, however those falls were not reported as an in-hospital fall. Due to the small sample size in our study, no conclusions can be drawn about the risk of falls in patients immediately post surgery. No studies in the scoping review inquired about in-hospital falls and may warrant further investigation.

Chapter 6: Clinical and Research Recommendations

Falls and their impact on the lives of older adults, their families, and the healthcare system are a primary concern. Although significant gains are seen with joint pain and function, patients with TJA do not return to levels of activity comparable to adults living in the community without TJA. Fear of falling and falls may be one reason for this discrepancy. Assessing fall risk would allow the identification of individuals who would likely benefit from services designed to reduce the risk for further injurious falls. Reducing subsequent frequency of falls and fall related injuries can result in a significant decrease in health-related costs, an essential consideration in the current managed health care environment. The following chapter lists the clinical and research recommendations of future studies.

6.1. Future Research Ideas

Based on the findings from this thesis, there are other areas worthy of additional investigation in relation to falls and falls risks in older adults. A number of new research questions that are perceived as worthwhile for further study are:

(1) Prospective studies with accurate falls ascertainment. There is still disagreement in the literature on the prevalence of falls in TJA participants, and whether or not it differs from community dwelling controls. Prevalence reports range from 8% up to 63% (Levinger et al., 2011; Riddle & Golladay, 2016). Future prospective studies with appropriate falls ascertainment methods and a clear falls description is needed in order to determine the extent to which TJA

patients are a high-risk group. In addition, a larger patient population study is needed to examine the prevalence of falls comparing patients waiting for and recovering from TJA.

(2) In hospital falls. TJA post-operative patients immediately after surgery may be at the highest risk of falls due to the interacting effects of several well established risk factors such as use of certain medications and gait instability. However, there are currently no studies in the literature that examine in-hospital falls in TJA patients. With a trend to a decreasing length of stay for TJA, falls upon discharge to home may be more of a concern.

(3) Recurrent fallers. Previous literature has identified recurrent fallers, or those who have fallen at least twice over the last year, as having a different set of characteristics than individuals who fall once or less in a given year. Future research should address risk factors in TJA participants who are recurrent fallers, and compare results to once-fallers or non-fallers.

(4) *Examining modifiable risk factors.* Future work should be focused on modifiable risk factors, specifically factors related to long-term conditions and medications specific to TJA participants such as pain medications and anti-inflammatory medications. Any falls prevention program can be modified to present the increased falls risk associated with specific medications. Older adults who take pain medications daily may benefit from reminders or suggestions on how to decrease falls risk in other ways (i.e. repairing or removing tripping hazards, wearing proper shoes, using non-slip mats etc.)

(5). Involving stakeholders. There is a lack of research that is qualitative or uses mixed-methods. Patients who fall may have unique insights into what causes falls. Future research should explore patient experiences with falls, clinician experiences with falls, and what patients and clinicians think will help in terms of handling the issue for falls in TJA participants. In

addition, investigation of whether or not fall intervention programs provided by health care staff or clinicians is effective or plausible is needed.

(6) Intervention studies. Although increased knowledge such as addressing risk factors is helpful for providing a framework for implementing falls prevention programs, and is often the primary step, most of the time falls are the result of the interaction between several risk factors (Rubenstein, 2006), and the results of these interactions are difficult to ascertain without prospective intervention studies. The effectiveness of proposed multi-factorial interventional strategy to prevent falls that directly targets patients who are waiting for TJA or are in the recovery phase should be examined in multiple joint arthroplasty clinic settings.

6.2. Clinical Implications of Researching Findings

Falls can happen to people of any age, although, falls among older adults are particularly dangerous due to high incidence of falling combined with high susceptibility to injuries because of comorbidities and functional decline (Rubenstein, 2006). Currently, several falls prevention initiatives exist in Canada. While many programs acknowledge the need for specialized falls prevention programs that target high risk groups, there are few that address TJA patients. According to the findings, TJA participants may not be at a higher risk of falls as compared to community dwelling older adults, yet they are more fearful of falling and are inactive up to 5 years after surgery (Bradbury, Borton, Spoo, & Cross, 1998).

Recommendations based off the results of this study are:

(1) Education on proper maintenance and use of supports in TJA patients. Supports such as walkers and crutches are mandatory to take weight off of a patient's lower body after surgery, and walkers are regarded as the support that provides the most stability after TJA surgery. The

results of the survey highlight a need for emphasis on safe practices with walkers, which can be achieved through patient education on falls in the pre-operative education sessions that many TJA participants received prior to surgery.

(2) Reviewing medications in TJA patients. Reviewing TJA medications such as pain-relievers and anti-inflammatory medications that are known risk factors for falling (Hegeman et al., 2009)may be one relatively easy intervention that can be implemented for this patient population. Because patients review their current list of medications with clinicians prior to and after surgery, a falls prevention check can be quickly assessed by a health care provider.

(3) Addressing fear of falling appropriately. An older adult with low fall-related efficacy may not necessarily need falls intervention, especially if their fear encourages behaviours that protect them from falling (i.e. wearing proper shoes, not engaging in dangerous activities like standing on a chair to reach for something, etc.). However, when low fall-related efficacy leads to unwillingness to engage in physical activity, then fear of falling may need to be addressed as a risk factor.

A number of practical factors can be implemented to minimize falls and fear of falling in patients with TJA. Further research, however, is warranted in the areas of activity limitation after surgery so that falls, risk factors and fear of falling can be better understood in patients with TJA.

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Appendices

Appendix A: Ethics Approval Form

Health Research Ethics Board

308 Campus Tower
University of Alberta, Edmonton, AB T6G 1K8
p. 780.492.9724 (Biomedical Panel)
p. 780.492.0302 (Health Panel)
p. 780.492.0459
p. 780.492.0839
f. 780.492.9429

Approval Form

Date:	October 21, 2016
Study ID:	Pro00065389
Principal Investigator:	Catherine Jones
Study Title:	Falls and fear of falling in older adults over 60 who have undergone total hip and knee arthroplasty
Approval Expiry Date:	Friday, October 20, 2017

Approved Consent Form:	Approval Date	Approved Document
	10/21/2016	Information Letter - Oct 14. .doc

Sponsor/Funding Agency:	Alberta Innovates Health Solutions		AIHS	Canada

RSO-Managed Funding:	Project ID	Project Title	Speed Code	Other Information
View	RES0028757	AIHS GSPOR 201500647		

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel . Your application, including the following, has been reviewed and approved on behalf of the committee.;

- Recruitment Poster (10/14/2016)
- Survey for Oct 19,2016
- Survey for Hip Knee Oct 19, 2016
- Script Oct 14 2016.
- References for Ethics Application (9/16/2016)
- Information Package Cover Letter (Distributed at End of Study) (9/22/2016)
- Information Package Self Assessment on Risk of Falling (9/16/2016)
- Information Package How to Prevent Falls: Key Messages (9/16/2016)
- Information Package How to Get Up After A Fall (9/16/2016)
- Information Package Statistics (9/16/2016)

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Alberta Health Services or other local health care institutions for the purposes of the research. Enquiries regarding Alberta Health Services approvals should be directed to (780) 407-6041. Enquiries regarding Covenant Health should be directed to (780) 735-2274.

Sincerely,

Doug Hill, PEng, MBA
Member, Health Research Ethics Board - Health Panel

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix B: Search Strategy for Scoping Review

Pubmed (for epub ahead of print only)
Date searched: April 6, 2017
Results: 5
pubstatusaheadofprint AND osteoarthritis AND (hip arthroplasty or joint arthroplasty or knee arthroplasty or hip replacement or knee replacement or joint replacement) AND (fall OR falls OR falling OR fallers OR faller)

Medline (Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present)
Date searched: April 6, 2017
Results: 174

1. exp Osteoarthritis/
2. osteoarthriti*.mp.
3. 1 or 2
4. hip joint/ or hip/
5. Knee Joint/ or Knee/
6. "prostheses and implants"/ or joint prosthesis/
7. arthroplasty/ or arthroplasty, replacement/
8. (4 or 5) and (6 or 7)
9. hip prosthesis/ or knee prosthesis/
10. arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/
11. ((total or complete) adj6 (hip or hips or knee or knees) adj6 (arthroplast* or prosthe* or replace* or implant*)).mp.
12. (((total or complete) adj6 joint adj6 (arthroplast* or prosthe* or replace* or implant*)) and (hip or hips or knee or knees)).mp.
13. (TKA or THA or TJA or TKR or TJR or THR).ti.
14. or/8-13
15. Accidental Falls/
16. (fall* or activities-specific balance confidence).mp.
17. 15 or 16
18. 3 and 14 and 17

CENTRAL (OVID Platform) EBM Reviews - Cochrane Central Register of Controlled Trials May 2016
Date searched: inception to July 5, 2016
Results: 25
Search strategy identical to Medline above

Cochrane Central Register of Controlled Trials (Wiley Interface)
Date searched: July 2016 - April 2017
Results: 2
osteoarthrit*:ti,ab,kw and fall* or "activities-specific balance confidence":ti,ab,kw and "hip arthroplast*" or "joint arthroplast*" or "knee arthroplast*" or "hip replacement*" or "knee replacement*" or "joint replacement*":ti,ab,kw Publication Year from 2016 to 2017, in Trials

Embase (OVID Platform) 1974 to 2017 April 05
Date searched: April 6, 2017
Results: 293

1. exp osteoarthritis/
2. osteoarthriti*.mp.
3. 1 or 2
4. exp knee arthroplasty/ or exp total hip prosthesis/ or exp total knee replacement/
5. exp knee arthroplasty/ or exp hip arthroplasty/ or exp total hip prosthesis/ or exp total knee replacement/
6. knee prosthesis/ or hip prosthesis/
7. (arthroplasty/ or joint prosthesis/) and (knee/ or hip/)
8. ((total or complete) adj6 (hip or hips or knee or knees) adj6 (arthroplast* or prosthe* or replace* or implant*)).mp.
9. (((total or complete) adj6 joint adj6 (arthroplast* or prosthe* or replace* or implant*)) and (hip or hips or knee or knees)).mp.
10. (TKA or THA or TJA or TKR or TJR or THR).ti.
11. or/4-10
12. falling/
13. fall risk assessment/
14. (fall* or activities-specific balance confidence).mp.
15. or/12-14
16. 3 and 11 and 15

CINAHL Plus with Full Text (EBSCO Interface)
Searched: April 6, 2017
Results: 45
Search modes: Boolean/Phrase

S1 (MH "Osteoarthritis+") OR osteoarthrit*

S2 ((MH "Arthroplasty, Replacement, Hip") OR (MH "Arthroplasty, Replacement, Knee")) OR ((total or complete) n6 (hip or hips or knee or knees) n6 (arthroplast* or prosthe* or replace* or implant*)) OR (((total or complete) n6 joint n6 (arthroplast* or prosthe* or replace* or implant*)) and (hip or hips or knee or knees)) OR (TKA or THA or TJA or TKR or TJR or THR)

S3. ((MH "Accidental Falls") OR (MH "Safety Status: Falls Occurrence (Iowa NOC)") OR (MH "Fall Risk (Saba CCC)") OR (MH "Fall Risk Assessment Tool") OR (MH "Hendrich Fall Risk Model") OR (MH "Morse Fall Scale")) OR (fall* or activities-specific balance confidence)

S4. S1 AND S2 AND S3

Web of Science (ISI Interface)
Searched: April 6, 2017
Databases: Web of Science Core Collection
Results: 82

#1 TI=(TKA OR THA OR TJA OR TKR OR TJR OR THR)

#2 TS=((total or complete) NEAR/4 joint NEAR/4 (arthroplast* or prosthe* or replace* or implant*)) AND TS=(hip or hips or knee or knees)
#3 TS=((total or complete) NEAR/4 (hip or hips or knee or knees) NEAR/4 (arthroplast* or prosthe* or replace* or implant*))
#4 TS=(TKA or THA or TJA or TKR or TJR OR THR) AND TS=((joint or hip or hips or knee or knees) NEAR/4 (arthroplast* or prosthe* or replace* or implant*))
#5 #1 OR #2 OR #3 OR #4
#6 TS=osteoarthrit*
#7 TS=(fall* or "activities-specific balance confidence")
#8 #5 AND #6 AND #7

SCOPUS
Searched: April 6, 2017
Results: 240

TITLE-ABS-KEY (osteoarthrit*) AND (TITLE-ABS-KEY (fall* OR "activities-specific balance confidence") AND TITLE-ABS-KEY ("hip arthroplast*" OR "joint arthroplast*" OR "knee arthroplast*" OR "hip replacement*" OR "knee replacement*" OR "joint replacement*") OR TITLE (tja OR tka OR tha OR tkr OR tjr OR thr))

Total: 866

Appendix C: Survey

Edmonton Hip and Knee Clinic Falls Survey

Please take a few minutes to fill out this survey. If you have any questions, please ask. Your answers will be kept confidential. Thank you for your time and participation.

General Participant Information

What is your gender? ☐ Male ☐ Female

What is your date of birth? _____Day _____Month _____Year

What are the first three digits of your postal code? _____ _____ _____

How tall are you **without** shoes on?_____Feet_____ Inches

How much do you weigh? _____ Pounds

What is your marital status?

☐ Married/Common-Law
☐ Divorced/Separated/Widowed
☐ Single/Never Married

What is your employment status?

☐ Part Time/Casual ☐Full Time
☐ Disability Leave ☐Retired
☐ Unemployed

How many years of schooling have you completed? (Circle appropriate year)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19+

What joint was replaced or the joint that you are waiting to replace

☐Hip ☐Knee
Which Side? ☐Left ☐Right

What is the **DATE** of your surgery (relevant to today's appointment)?

Day _____ Month_____ Year_____

☐ No date has been set

Have you ever had any other knee or hip joint replaced? ☐ Yes ☐ No

If **Yes,** what was the joint was replaced? (Check all that apply).

☐Hip Which Side? ☐Left ☐Right

☐Knee Which Side? ☐Left ☐Right

What joints have arthritis (Check all that apply)? Leave blank if none.

☐ Right hip ☐Left hip
☐ Right knee ☐Left knee ☐Wrist/Hands
☐ Ankles/Feet ☐Shoulders ☐Other _____

Falls Information

Note: A fall is defined as a sudden loss of balance or gait that leads you land on the ground or a lower level than where you were originally.

In the past 12 months, did you have any falls? ☐ Yes ☐ No

Have you fallen after receiving your most recent joint replacement? ☐ Yes ☐ No ☐ N/A

If **YES**, how many falls have you had in the past 12 months?

_____

When did your fall(s) happen? Check all that apply. Was it:

☐ Less than 1 month ago
☐ 1 month to less than 3 months ago
☐ 3 months to less than 6 months ago
☐ 6 or more months ago?

If **YES**, where did you fall? (Check all that apply)

☐ Inside your home
☐ Outside your home, but inside a building
☐ Outdoors
☐ While you were in the hospital

Do you have stairs in your home? ☐ Yes ☐ No

What has been your most serious injury or problem due to a fall within the past 12 months?

☐ No serious injury
☐ Sprain/strain
☐ Bruises or cuts
☐ Fracture of hip or leg
☐ Head injury
☐ Fracture of back/vertebra
☐ Fracture of arms or wrist

Did you receive any medical attention from a health professional within 48 hours following any of these falls injuries? ☐ Yes ☐ No

If Yes - Where did you go to seek medical attention? (Check all that apply)

☐ Walk-In Clinic
☐ Hospital Emergency Room
☐ Hospital Outpatient Clinic
☐ Community Health Center
☐ Telephone Health Line (for example, Health Link)
☐ Other, Specify _____

Were you admitted for overnight care due to your falls-related-injury? ☐ Yes ☐ No

Fear'of'Falling'

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

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

No Confidence ***Completely Confident***

Question: How confident are you that you will *not* lose your balance or become unsteady when you…

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

Are you afraid of falling?

☐Not at all afraid
☐Slightly afraid
☐Somewhat afraid
☐Very afraid

Medical Information

We are interested in any “long-term conditions” which are expected to last or have already lasted 6 months or more and that have been diagnosed by a health professional.
Check all that apply.

☐ Chronic pain (Back, neck, migraine, abdomen, chest)
☐ Serious joint/bone problems (e.g., Paget's)
☐ Osteoporosis
☐ Arthritis/rheumatism, excluding fibromyalgia
☐ Circulatory problems
☐ High blood pressure
☐ Diabetes
☐ Stroke
☐ Heart disease
☐ Asthma
☐ Eye problems
☐ Trouble hearing/deafness
☐ Paralysis/speech problems due to stroke
☐ Renal disease
☐ Urinary or bowel incontinence
☐ Mental health problems (e.g., depression, anxiety, panic)
☐ Parkinson's
☐ Multiple sclerosis
☐ None of the above

At the present time, would you say your eyesight using both eyes (with glasses or contact lenses, if you wear them) is:

☐ Excellent
☐ Good
☐ Fair
☐ Poor
☐ Very Poor
☐ Completely Blind

Which medications are you currently taking?

☐Antipsychotics ☐ Sedative or hypnotics ☐ Anti-depressants
☐Pain medication ☐ Anxiety medication ☐ None
☐Other_____

Physical Activity

Thinking about the level of physical activity you do every week in the past month, do you consider yourself to be . . .?

☐ Very physically active
☐ Moderately physically active
☐ A bit physically active
☐ Not physically active at all

How many flights of stairs can you climb without stopping? One flight is 13 steps.

_____

Generally, how far can you walk before you must stop to rest?

☐ Unlimited (10 blocks or longer)
☐ 6-10 blocks
☐1-5 blocks
☐ <1 block
☐ Indoors only

What limits you walking further?

☐No limitations ☐Pain/discomfort
☐Fatigue ☐Other (specify)_____

What types of supports do you use when walking? (Check all that apply)

☐None ☐Walker
☐One cane ☐Two canes
☐One crutch ☐Two crutches
☐Wheelchair ☐Other

Alcohol Consumption History

A drink refers to: (1) A bottle or small can of beer, cider, or cooler with 5% alcohol or small draft (2) A glass of wine with 12% alcohol content (3) A glass or cocktail containing 1oz. of spirit with 40% alcohol content

During the past 12 months, have you had a drink of beer, wine, liquor, or any other alcoholic beverage?

☐Yes
☐No

During the past 12 months, how often did you drink alcoholic beverages?

☐Less than once a month
☐Once a month
☐2-3 times a month
☐Once a week
☐2-3 times or more a week

In general, how would you say your health is (check one):

☐Excellent
☐Very good
☐Good
☐Fair
☐Poor

Thank you for taking the time to fill out our survey.

Interested in Survey Results?

Are you interested in having a researcher contact you about the findings of this study once it is completed?

☐ Yes | ☐ No

If you answered yes to the previous question, please fill out your contact information below. You can either have us mail you the information or email it to you. Otherwise, you may leave this section blank.

☐ I prefer to have it mailed to me (please leave your mailing information):

First Name _____ Last Name (Optional) _____

Mailing Address _____ City _____ Province _____ Postal Code _____

☐ I prefer to have it emailed to me (please leave your mailing information):

Email Address _____

Appendix D: Data Dictionary

Survey Name	Variable Type	Variable Name	Falls Question	Codes
General Participant Information				
Sex	Dichotomous	SEX	"What is your gender?"	0-Male 1-Female
Age	Continuous	AGE	"What is your date of birth?"	Day (0-31) Month (0-12) Year
Postal Code	String	POSTAL	"What are the first three digits of your postal code?"	N/A
Height	Continuous	HEIGHT	"How tall are you without shoes on? (Feet/Inches)	N/A
Weight	Continuous	WEIGHT	"How much do you weigh (Pounds)?"	N/A
Marital Status	Nominal	MARRIED	"What is your marital status?"	0 -Married/Common Law 1-Divorced/Separated/Widowed 2-Single/Never Married
Employment	Nominal	EMPLOY	"What is your employment status?"	0-Retired 1-Unemployed 2-Disability Leave 3-Part Time/Casual 4-Full Time
Schooling	Continuous	SCHOOL	"How many years of schooling have you completed?"	N/A
Joint Replaced	Nominal	JWR_1 (Hip) JWR_2 (Knee) JWR_3 (Left) JWR_4 (Right)	"What joint was replaced or the joint that you are waiting to replace?"	0=No 1=Yes
Date of surgery	Date	DATE	"What is the date of the surgery?"	Day/Month/Year 0=No date has been set
Pervious TJA (Y/N)	Nominal	OHK	"Have you had any other knee or hip joint replaced?"	0=No 1=Yes
Previous TJA (Joint)	Nominal	OHK_1 (Left Hip) OHK_2 (Right Hip)	"If yes, what was the joint that was replaced?"	0=No 1=Yes

		OHK_3 (Left Knee) OHK_4 (Right Knee)		
Arthritis	Nominal	ARTH_1 (Right Hip) ARTH_2 (Right Knee) ARTH_3 (Ankles/Feet) ARTH_4 (Left Hip) ARTH_5 (Left Knee) ARTH_6 (Shoulders) ARTH_7 (Wrist/Hands) ARTH_8 (Other)	"What other joints have arthritis?"	0=No 1=Yes
Falls Information				
Fall Status	Dichotomous	FLL_YR	"In the past 12 months, did you have any falls?"	0=No 1=Yes
Falls Since TJR	Count	FLL_TJR	"Have you fallen after receiving your most recent joint replacement?"	0=No 1=Yes
Number of Falls in Past Year	Continuous	FLL_TJR_NUM	"If YES, how many falls have you had in the past 12 months?"	N/A
Falls - When	Nominal	WHEN_1 (<1mo ago) WHEN_2 (1-2 mo ago) WHEN_3 (2-6 mo ago) WHEN_4 (6+ mo ago)	"When did your fall(s) happen? Check all that apply, was it:"	0=No 1=Yes
Falls - Where	Nominal	WHERE_1 (inside home) WHERE_2 (outside home) WHERE_3 (outdoors) WHERE_4 (in hospital)	"Where did you fall? Check all that apply:"	0=No 1=Yes
Falls - Stairs	Dichotomous	STAIR	"Do you have stairs in your home?"	0=No 1=Yes
Falls - Injury	Nominal	INJ_1 (No serious injury) INJ_2 (Sprain /strain) INJ_3 (Bruises/cuts) INJ_4 (Fracture of hip/leg) INJ_5 (Head injury) INJ_6 (Fracture of back) INJ_7 (Fracture of arm/wrist)	"What has been your most serious injury or problem due to a fall within the past 12 months?"	0=No 1=Yes
Medical Attention (MA)	Dichotomous	M_ATT	"Did you receive any medical attention from a health professional within 48	0=No 1=Yes

			hours following any of these falls injuries?"	
MA - Where	Dichotomous	M_ATT1 (Walk-In Clinic) M_ATT2 (Hospital ER) M_ATT3 (Hospital Outpatient) M_ATT4 (Health Center) M_ATT5 (Help Line - 811) M_ATT6 (Other)	"If yes, where did you go to seek medical attention?"	0=No 1=Yes
MA - Overnight	Dichotomous	OVER	"Were you admitted for overnight care due to your falls-related injury?"	0=No 1=Yes
Fear of Falling				
Activities Specific Balance Scale	Continuous	FOF1	"How confident are you that you will not lose your balance or become unsteady when you . . . walk around the house?"	0-100
Activities Specific Balance Scale	Continuous	FOF2	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF3	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF4	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF5	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF6	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF7	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF8	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF9	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100

Activities Specific Balance Scale	Continuous	FOF10	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF11	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF12	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF13	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF14	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF15	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Activities Specific Balance Scale	Continuous	FOF16	"How confident are you that you will not lose your balance or become unsteady when you . . .	0-100
Fear	Ordinal	FEAR	"Are you afraid of falling?	0 = Not at all afraid 1 = Slightly afraid 2 = Somewhat afraid 3 - Very afraid
Medical Information **Survey Question:** "we are interested in any long-term conditions that are expected to last or have already lasted 6 months or more and that have been diagnosed by a health professional, check all that apply:"				
Chronic Pain	Dichotomous	LTC1	"Chronic pain (back, neck, migraine, abdomen, chest)	0=No 1=Yes
Joint Problems	Dichotomous	LTC2	"Serious joint/bone problems (e.g., Paget's)	0=No 1=Yes
Osteoporosis	Dichotomous	LTC3	Osteoporosis	0=No 1=Yes
Arthritis	Dichotomous	LTC4	Arthritis/rheumatism, excluding fibromyalgia	0=No 1=Yes
Circulatory	Dichotomous	LTC5	Circulatory problems	0=No

				1=Yes
Blood Pressure	Dichotomous	LTC6	High blood pressure	0=No 1=Yes
Diabetes	Dichotomous	LTC7	Diabetes	0=No 1=Yes
Stroke	Dichotomous	LTC8	Stroke	0=No 1=Yes
Heart Disease	Dichotomous	LTC9	Heart Disease	0=No 1=Yes
Asthma	Dichotomous	LTC10	Asthma	0=No 1=Yes
Vision	Dichotomous	LTC11	Eye Problems	0=No 1=Yes
Hearing	Dichotomous	LTC12	Trouble Hearing/Deafness	0=No 1=Yes
Paralysis	Dichotomous	LTC13	Paralysis/speech problems due to stroke	0=No 1=Yes
Renal Disease	Dichotomous	LTC14	Renal Disease	0=No 1=Yes
Incontinence	Dichotomous	LTC15	Urinary or Bowel Incontinence	0=No 1=Yes
Mental Health	Dichotomous	LTC16	Mental Health Problems (e.g., depression, anxiety, panic)	0=No 1=Yes
Parkinson's (screening)	Dichotomous	LTC17	Parkinson's	0=No 1=Yes
Multiple Sclerosis (screening)	Dichotomous	LTC18	Multiple Sclerosis	0=No 1=Yes
None of the above	Dichotomous	LTC19	None of the above	0=No 1=Yes
Vision - Additional	Ordinal	EYE	"At the present time, would you say your eyesight using both eyes (with glasses or contact lenses, if you wear them) is:	0=Excellent 1=Good 2=Fair 3=Poor 4=Very Poor 5=Completely Blind
Medications	Nominal	MED1 (Antipsychotics) MED2 (Sedative or hypnotics) MED3 (Anti-depressants)	"Which medications are you currently taking?"	0=No 1=Yes

		MED4 (Pain medications) MED5 (Anxiety medications) MED6 (None) MED7 (Other)		
Physical Activity				
Self-Report Activity Level	Nominal	ACTIVE	"Thinking about the level of physical activity you do every week in the past month, do you consider yourself to be . . .?"	0=Very physically active 1=Moderately physically active 2=A bit physically active 3=Not physically active at all
Stair Climbing	Continuous	FLIGHT	"How many flights of stairs can you climb without stopping?"	N/A
Walking	Ordinal	FAR	"Generally, how far can you walk before you must stop to rest?"	0=Unlimited (10+blocks) 1=6-10 blocks 2= 1-5 blocks 3= <1 block 4=Indoors only
Limits to Walking	Nominal	FAR_LIMIT1 (No limitations) FAR_LIMIT2 (Fatigue) FAR_LIMIT3 (Pain/discomfort) FAR_LIMIT4 (Other)	"What limits you walking further?"	0=No 1=Yes
Supports	Nominal	SUP0 (None) SUP1 (Walker) SUP2 (1 Cane) SUP3 (2 Canes) SUP4 (1 Crutch) SUP5 (2 Crutches) SUP6 (Wheelchair) SUP7 (Other)	"What types of supports do you use when walking? (Check all that apply)	0=No 1=Yes
Alcohol Consumption History				
Drinking Status	Dichotomous	DRINK	"During the past 12 months, have you had a drink of beer, wine, liquor, or any other alcoholic beverage?"	0=No 1=Yes
Drinking frequency	Ordinal	ODRINK	"During the past 12 months, how often did you drink alcoholic beverages?"	0=Less than once a month 1=Once a month 2=2-3 times a month 3 Once a week

				4= 2-3 times or more a week
General Health	Ordinal	GHEALTH	"In general, how would you say your health is?"	0=Excellent 1=Very good 2=Good 3=Fair 4=Poor

Appendix E:Risk Factors Measured in Survey

Factors Measured in Survey

Biological	Behavioural
Number of Chronic illnesses	Fear of falling
Chronic pain	Polypharmacy (4+ Medications)
Stroke	Taking antipsychotics
Osteoporosis	Taking pain medication
Arthritis	Taking sedatives/hypnotics
High blood pressure	Taking anti-depressants
Vision problems	Lack of exercise
Diminished proprioception (trouble hearing/deafness)	Stair-climbing ability
Urinary/bowl incontinence	Walking ability
Mental health problems	Use of a walker
	Alcohol consumption

Appendix F: Supplemental Tables

Supplemental Table 1: Association between total joint arthroplasty and fall status using multiple logistic regression, adjusting for age and sex.

	OR (95% CI)	***p*-value**
Age	0.96, 0.92-1.00	0.094
Sex	1.34 (0.7-2.28)	0.272
Community Cohort (Reference)	-	-
Total Joint Arthroplasty	1.19 (0.68-2.07)	0.525

Supplemental Table 2: Effect of type of joint replaced on fall status

		OR (95% CI)	***p*-value**
Age, years (mean, sd)	71.2 (6.6)	0.96 (0.92-1.01)	0.136
Gender, (% female)	117, 59%	1.32 (0.71-2.4)	0.33
Knee Arthroplasty n (%)	110 (56%)	1.00 (Reference)	
Hip Arthroplasty n (%)	88 (44%)	0.98 (0.52-1.8)	0.94

Supplemental Table 3: Total number of risk factors measured and present per individual in the total joint arthroplasty group compared to the community group.

	Total Joint Arthroplasty	Community	*p*
Total number of risk factors per individual (mean, SD)	6.3 (3.2) Min:0 Max: 15	3.7 (2.5) Min:1 Max: 11	**<0.01**

Supplemental Table 4: Demographic, medical, ambulatory, and behavioural profiles between three groups: pre-operative participants, post-operative participants, and community controls

	Pre-Operative (n=114)	Post Operative (n=84)	Community (n=100)
TKA THA Other joint involvement Previous hip replacement Previous knee replacement	54 (47%) 60 (52%) 57 (50%), 27 (23%) 30 (26%)	50 (59%) 34 (41%) 31 (37%) 12 (14%) 19 (23%)	N/A N/A 0
Demographic			
Age, mean (SD)	71.1 (6.5)	70.5 (6.8)	71.4 (5.7)
Sex, female	64 (56%)	53 (63%)	59 (59%)
Marital status, n(%)			
Married/Common Law	90 (78%)	61 (72%)	64 (64%)
Divorced/Widowed	24 (21%)	22 (26%)	26 (26%)
Never Married/Single	0	1 (1%)	10 (10%)
Employment n(%)			
Retired	91 (79.8%)	61 (72%)	87 (87%)
Unemployed	4 (3.5%)	0	3 (3%)
Disability Leave	4 (3.5%)	4 (4.8%)	1 (1%)
Part Time/Casual	2 (1.8%)	7 (8.3%)	2 (2%)
Full Time	13 (11.4%)	12 (14.3%)	7 (7%)
Education years, mean (SD)	14.15 (10.7)	12.36 (3.7)	14.0 (3.1)
Body mass index, kg/m2	30.5 (6.1)	30.2 (5.1)	27.4 (5.2)
Comorbid conditions, mean (SD) No conditions	3.56 (2.01) 8 (7%)	2.6 (1.3) 10 (12%)	2.34 (1.75) 15 (15%)
High blood pressure	55 (48%)	32 (38%)	44 (44%)
Arthritis	73 (64%)	40 (48%)	34 (34%)
Eye problems	31 (27%)	7 (8%)	24 (24%)
Self-report chronic pain	48 (42%)	12 (14%)	23 (23%)
Serious joint/bone problems	37 (33%)	10 (11.9%)	5 (5%)
Osteoporosis	33 (29%)	17 (20%)	18 (18%)
Circulatory problems	8 (7.02%)	47 (55.9%)	6 (6%)
Diabetes	31 (27%)	4 (5%)	13 (13%)
Stroke or paralysis/speech problems due to stroke	2 (2%)	4 (5%)	2 (2%)
Heart disease	9 (8%)	6 (7%)	13 (13%)
Asthma	16 (14%)	8 (10%)	13 (13%)
Trouble hearing/deafness	29 (25%)	12 (15%)	21 (21%)
Renal disease	1 (8%)	0 (0%)	2 (2%)
Urinary or bowel incontinence	20 (18%)	5 (6%)	9 (9%)
Mental health problems	10 (9%)	5 (6%)	6 (6%)
Parkinson's	0	0	0
Multiple sclerosis	0	0	0
Medications Number of medications, mean (SD)	1.8 (1.4)	1.9 (1.5)	1.1 (1.4)
None	17 (14%)	15 (18%)	33 (33%)
Pain	75 (65%)	39 (46%)	17 (17%)

Blood Pressure	13 (11.4%)	22 (26%)	12 (12%)
Anti-Depressants	21 (18%)	11 (13%)	7 (7%)
Anti-Psychotics	1 (1%)	0	0
Sedatives or Hypnotics	6 (5%)	3 (4%)	2 (2%)
Anxiety Medication	1 (1%)	4 (5%)	1 (1%)
Self- report general health			
Excellent	10 (8%)	12 (14%)	17 (17%)
Very Good	35 (31%)	32 (38%)	42 (42%)
Good	53 (46%)	28 (33%)	32 (32%)
Fair	16 (14%)	11 (13%)	9 (9%)
Poor	0 (0%)	1 (1%)	0 (0%)
Ambulatory			
Walking devices None	22 (20%)	7 (8%)	89 (89%)
Cane	61 (53%)	43 (51%)	9 (9%)
Crutch	9 (8%)	15 (18%)	0
Walker	22 (19%)	19 (23%)	2 (2%)
Walk distance			
Unlimited	10 (9%)	4 (5%)	66 (66%)
6-10 blocks	10 (9%)	42 (50%)	15 (15%)
1-5 blocks	38 (34%)	23 (27%)	14 (14%)
Less than 1 block	35 (30%)	15 (18%)	3 (3%)
Indoors only	20 (17%)	0 (0%)	2 (2%)
Limits to walking			
Pain	96 (84%)	34 (40%)	21 (21%)
Fatigue	20 (18%)	24 (29%)	25 (25%)
No Limits	5 (4%)	13 (15.4%)	54 (54%)
Flights of Stair able to climb, mean (SD)	1.54 (1.9)	1.91 (2.36)	3.7 (3.05)
Behavioural Activity ("Would you consider yourself to be")			
Very Active	5 (4%)	4 (4.7%)	21 (21%)
Moderately Active	42 (37%)	42 (50%)	56 (56%)
A Bit Active	45 (40%)	23 (27%)	19 (19%)
Not at all Active	21 (18%)	15 (18%)	4 (4%)
Alcohol consumption			
Does not drink	54 (47%)	46 (54%)	43 (43%)
Once a month	22 (21%)	10 (11%)	25 (25%)
Once a week	38 (33%)	28 (33%)	32 (32%)

Supplemental Table 5**:** Fallers, number of falls, and recurrent fallers in post-operational participants

Follow up clinic visit	**n**	**Number days since surgery Median (IQR)**	**Number patients who had at least one fall in the past year, n (%)**	**Number of falls in the past year**	**Recurrent fallers in the past year, n (%)**	***Number patients who fell after surgery, n (%)***	***Number of falls, after surgery***
2 Weeks	8	13 (8-16)	5 (63%)	8	2 (25%)	2 (25%)	3
6 Weeks	49	44 (42-51)	12 (25%)	22	4 (8%)	4 (8%)	5
3 Months	9	93 (84-94)	1(11%)	2	1 (11%)	0	0
1 Year	18	367 (339-403)	5 (27%)	12	3 (17%)	5 (27%)	12
Total	**84**	**132 (42-92.5)**	**23 (27%)**	**44**	**10**	**11**	**20**

*Range is reported

Supplemental Table 6: The association between The Activities-specific Balance Confidence scale and rating of fear of falling in total joint arthroplasty group and community dwelling controls

Grouping (n)	ABC Mean Score Overall (SD)* (n=298)		TJA Cohort (n=198)	THA (n=88)	TKA (n=110)	Community (n=100)
			36	19	17	34
"Not fearful"	134	86.7 (19.2)	84.1 (21.0)	80.1 (26.8)	88.6 (11.3)	96.7 (5.3)
"A little fearful"	35	62.5 (21.1)	85 71.3 (22.6)	36 67.9 (22.6)	49 73.7 (22.0)	49 89.8 (7.9)
"Somewhat fearful"	59	77.7 (21.1)	46 59.7 (18.7)	19 63.1 (18.0)	27 57.3 (18.8)	13 71.7 (23.0)
"Very fearful"	70	53.3 (25.0)	31 46.5 (22.3)	14 44.8 (18.2)	17 50.1 (24.8)	4 54.3(28.9)

* A Spearman's correlation was run to assess the relationship between ABC scores and fear rating using a sample of 298 participants. There was a strong negative correlation between ABC scores and fear rating (0=not afraid at all, 1=slightly afraid, 2= somewhat afraid, 3=very afraid), which was statistically significant, rho = .51, p = .0000

**TJA = total joint arthroplasty; THA = total hip arthroplasty, TKA = total knee arthroplasty

Supplemental Table 7**:** Post-operative participants that reported at least one fall after surgery

Follow up clinic visit	**n**	**ID**	**When was the fall?**	**How long after surgery did they fall?**	**True Post-Op Fall?**
2 Weeks	2	119 119 113	under 1 mo. under 1 mo. 3-6 mo. ago	w/in 2 wk w/in 2 wk -	Yes Yes No
6 Weeks	4	144 126 79 79 202	1-3 mo. ago 3-6 mo. ago 1-3 mo. ago under 1 mo. 1-3 mo ago.	w/in 2 weeks - w/in 2 weeks after 2 weeks w/in 2 week	Yes No Yes Yes Yes
3 Months	0	-	-	-	-
1 Year	5	83 88 88 85 85 85 85 85 82 171	3-6 mo. ago 3-6 mo. ago 3-6 mo. ago 1-3 mo. ago 3-6 mo ago 6+ mo ago 1-6+ mo ago 1-6+ mo ago Under 1 mo. 3-6 mo. ago	6-9 mo. 6-9 mo. 6-9 mo. 9-11 mo. 6-9 mo 6-12 mo. 6-12 mo. 6-12 mo. 11 mo. 6-9 mo.	Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes
Total	**11**	**17**	**-**		**-**

*w/in = within, mo=months, wk=week

Appendix G: Stepwise Backward and Stepwise Forward Selection Procedure

Stepwise logistic regression was completed to select important predictors of falls in total joint arthroplasty participants

Step 1: List out the variables in the model

Data Dictionary for Stepwise Logistic Regression

Risk Factor (TJA)	**n**	**Assigned Variable Name**
Number of comorbid conditions		
0-3	81	LTCG* =0
3+	117	LTCG = 1
Self-report chronic pain Yes No	 66 132	 LTC1 = 1 LTC1 = 0
Stroke Yes No	 6 192	 LTC8 = 1 LTC8 = 0
Osteoporosis Yes No	 50 148	 LTC3 = 1 LTC3 = 0
Arthritis Yes No	 120 78	 LTC4=1 LTC4=0
High blood pressure Yes No	 99 99	 LTC6=1 LTC6=0
Eye problems Yes No	 41 157	 LTC11=1 LTC11=0
Trouble hearing/deafness Yes No	 42 156	 LTC12=1 LTC12=0
Urinary or bowl incontinence Yes No	 25 173	 LTC15=1 LTC15=0
Mental health problems Yes No	 15 183	 LTC16=1 LTC16=0
ABC (continuous)	198	FOFTOTAL
Joint Replaced	198	JWR_1 (0=Hip, 1=Knees)
Medications		

None	37	MEDTOTALR = 0
1-3	137	MEDTOTALR = 1
4+	24	MEDTOTALR = 2
Use of anti-psychotics		
Yes	2	MED1=1
No	196	MED1=0
Use of pain medication		
Yes	114	MED4=1
No	84	MED4=0
Use of sedatives/hypnotics		
Yes	10	MED2=1
No	188	MED2=0
Use of anti-depressants		
Yes	32	MED3=1
No	166	MED3=0
Activity Level		
Activity, not active/a bit active (ref)	93	ACTIVER=0
Moderately active/very active	105	ACTIVER=1
Stairs		
Unable to do stairs /<1 flight	140	FLIGHTR=0
More than 1 flight of stairs	58	FLIGHTR=1
Distance walked		
Unable to Walk/1-5 Blocks	109	FARR=0
More than 6 Blocks	89	FARR=1
Walker Use		
Yes	41	SUP1=1
No	157	SUP1=0
Alcohol consumption		
Yes	64	DRINK=1
No	134	DRINK=0

*TJA = total joint arthroplasty group
*LTC = long term condition

Step 2: Conduct forward stepwise regression

Variables were included in the model if Univariate analysis showed significance at p=0.20 when entered independently

```
. stepwise, pe(0.05) pr(0.2): logit FLL_YR LTC1 LTC12 LTC15 LTC16 LTC11 LTC6 LTC4 LTC3 LTC8 LTCG FOFTOTAL MEDTOTALR MED2 MED1 MED3 MED4
ACTIVE FLIGHT FAR SUP1 DRINK JWR_1
note: MED1 dropped because of estimability
note: o.MED1 dropped because of estimability
note: 2 obs. dropped because of estimability
                begin with full model
p = 0.9654 >= 0.2000  removing LTC8
p = 0.8985 >= 0.2000  removing LTC4
p = 0.8566 >= 0.2000  removing ACTIVE
p = 0.8224 >= 0.2000  removing MED4
p = 0.7654 >= 0.2000  removing LTC11
p = 0.7549 >= 0.2000  removing JWR_1
p = 0.6435 >= 0.2000  removing FAR
p = 0.6041 >= 0.2000  removing LTC16
p = 0.5501 >= 0.2000  removing LTC12
p = 0.5126 >= 0.2000  removing LTC3
p = 0.3780 >= 0.2000  removing MED2
p = 0.3406 >= 0.2000  removing LTC15
```

```
p = 0.3719 >= 0.2000  removing LTCG
p = 0.3029 >= 0.2000  removing FLIGHT
p = 0.2384 >= 0.2000  removing MED3
p = 0.2186 >= 0.2000  removing SUP1
p = 0.3079 >= 0.2000  removing DRINK

Logistic regression                     Number of obs     =        195
                                        LR chi2(4)        =      19.10
                                        Prob > chi2       =     0.0008
Log likelihood = -108.26893             Pseudo R2         =     0.0811

------------------------------------------------------------------------------
     FLL_YR |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
       LTC1 |   .7801459   .3463504     2.25   0.024     .1013116    1.45898
   FOFTOTAL |   -.013183   .0068243    -1.93   0.053    -.0265584    .0001924
       LTC6 |   .5980235   .3424808     1.75   0.081    -.0732266    1.269274
  MEDTOTALR |    .653766   .3231561     2.02   0.043     .0203916    1.28714
      _cons |  -1.259628   .6162731    -2.04   0.041    -2.467501   -.0517552
------------------------------------------------------------------------------

. xi: logit FLL_YR SEX AGE LTC1 FOFTOTAL LTC6 MEDTOTALR, or
```

```
. xi: logit FLL_YR SEX AGE LTC1 FOFTOTAL LTC6 MEDTOTALR, or

Iteration 0:   log likelihood = -118.84781
Iteration 1:   log likelihood = -107.99077
Iteration 2:   log likelihood = -107.70639
Iteration 3:   log likelihood = -107.70553
Iteration 4:   log likelihood = -107.70553

Logistic regression                     Number of obs     =        198
                                        LR chi2(6)        =      22.28
                                        Prob > chi2       =     0.0011
Log likelihood = -107.70553             Pseudo R2         =     0.0938

------------------------------------------------------------------------------
      FLL_YR | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         SEX |   1.133395   .3961333     0.36   0.720     .5713176    2.24846
         AGE |    .943126   .0249012    -2.22   0.027     .8955619    .9932164
        LTC1 |   1.961088   .6836898     1.93   0.053     .9902497    3.883735
    FOFTOTAL |   .9876011   .0067495    -1.83   0.068     .9744604    1.000919
        LTC6 |   2.017805   .6943341     2.04   0.041     1.027964    3.960781
   MEDTOTALR |   1.728701   .5506663     1.72   0.086     .9259239    3.227487
       _cons |   16.83466   32.71259     1.45   0.146     .3734009    758.9851
------------------------------------------------------------------------------
```

Logistic regression outcomes for factors affecting falls in TJA participants using forwards selection

Variable	Odds Ratio	95% CI	Decision
Age	0.94	0.89, 0.99	IN
Sex	1.13	0.54, 2.24	IN
Chronic pain (LTC1)	1.96	0.99, 3.88	OUT
Fear of falling (FOFTOTAL)	0.99	0.91, 1.00	OUT
High Blood Pressure (LTC6)	2.0	1.02, 3.09	IN
Total number of medications (MEDTOTALR)	1.72	0.92-3.22	OUT

Step 3: Check the goodness of fit for the model

```
. estat gof

Logistic model for FLL_YR, goodness-of-fit test

      number of observations =      198
```

```
number of covariate patterns =      197
        Pearson chi2(190) =      199.03
             Prob > chi2 =      0.3121
```

The test was non-significant with chi2=199 (DOF=190) and p=0.31, which means the model gives a good fit to the data.

Step 4: Conduct stepwise backwards selection

```
stepwise, forward pe(0.05) pr(0.2): logit FLL_YR LTC1 LTC12 LTC15 LTC16 LTC11 LTC6 LTC4 LTC3 LTC8 LTCG FOFTOTAL
>  MEDTOTALR MED2 MED1 MED3 MED4 ACTIVE FLIGHT FAR SUP1 DRINK JWR_1
note: MED1 dropped because of estimability
note: o.MED1 dropped because of estimability
note: 2 obs. dropped because of estimability
                begin with empty model
p = 0.0025 <  0.0500  adding   LTCG
p = 0.0410 <  0.0500  adding   MEDTOTALR

Logistic regression                     Number of obs     =        195
                                LR chi2(2)      =      14.32
                                Prob > chi2     =     0.0008
Log likelihood = -110.65826             Pseudo R2       =     0.0608

------------------------------------------------------------------------------
      FLL_YR |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        LTCG |   .9910807   .3560708     2.78   0.005     .2931948    1.688967
   MEDTOTALR |   .6489588   .3176029     2.04   0.041     .0264686    1.271449
       _cons |  -2.148504   .4270435    -5.03   0.000    -2.985494   -1.311515
------------------------------------------------------------------------------

. . xi: logit FLL_YR SEX AGE LTCG MEDTOTALR, or

Iteration 0:   log likelihood = -118.84781
Iteration 1:   log likelihood = -109.49593
Iteration 2:   log likelihood = -109.25545
Iteration 3:   log likelihood =  -109.2548
Iteration 4:   log likelihood =  -109.2548

Logistic regression                     Number of obs     =        198
                                LR chi2(4)      =      19.19
                                Prob > chi2     =     0.0007
Log likelihood =  -109.2548             Pseudo R2       =     0.0807

------------------------------------------------------------------------------
      FLL_YR | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         SEX |   1.151775   .3941164     0.41   0.680     .5889818    2.252337
         AGE |   .9367771   .0246233    -2.48   0.013     .8897385    .9863026
        LTCG |   2.914266    1.07411     2.90   0.004     1.415149    6.001449
   MEDTOTALR |   1.717015   .5438059     1.71   0.088      .922965    3.194208
       _cons |   11.22995   20.75811     1.31   0.191     .2998932    420.5224
------------------------------------------------------------------------------
```

Logistic regression outcomes for factors affecting falls in TJA participants using backwards selection

Variable	Odds Ratio	95% CI	Decision
Age	0.94	0.89, 0.98	IN
Sex	1.15	0.58, 2.25	IN
LTCG	2.91	1.42, 6.00	IN
MEDTOTALR	1.71	0.92, 3.19	IN

Step 5: Check the goodness of fit for the final model

```
Logistic model for FLL_YR, goodness-of-fit test

      number of observations =      198
number of covariate patterns =      127
        Pearson chi2(122) =      117.88
             Prob > chi2 =      0.5885
```

The test was non-significant with chi2=117.88 (DOF=122) and p=0.59, which means the model gives a good fit to the data.

Step 6: Regression Diagnostics (Correlation)

Logistic Regression Diagnostics (Correlation)

```
. correlate SEX AGE LTC1 LTC12 LTC15 LTC16 LTC11 LTC6 LTC4 LTC3 LTC8 LTCG FOFTOTAL MEDTOTALR MED2 MED1 MED3 MED4 ACTIVE FLIGHT FAR SUP1 DRINK JWR_1
(obs=197)

             |      SEX      AGE     LTC1    LTC12    LTC15    LTC16    LTC11     LTC6     LTC4     LTC3     LTC8     LTCG FOFTOTAL MEDTOT~R     MED2
-------------+---------------------------------------------------------------------------------------------------------------------------------------
         SEX |   1.0000
         AGE |   0.0662   1.0000
        LTC1 |   0.1037  -0.0245   1.0000
       LTC12 |  -0.1307   0.2153   0.0657   1.0000
       LTC15 |   0.0589   0.1905   0.1677   0.0384   1.0000
       LTC16 |   0.0065  -0.0958   0.1649   0.0414  -0.0484   1.0000
       LTC11 |   0.0371   0.1630   0.1289   0.3007   0.1592  -0.0973   1.0000
        LTC6 |   0.0061   0.0808  -0.0936  -0.0099   0.0950   0.0206  -0.0227   1.0000
        LTC4 |   0.1251   0.1259   0.3032   0.0827   0.1111   0.1150   0.0474  -0.0041   1.0000
        LTC3 |   0.2503  -0.0013   0.0869   0.1895   0.1037   0.1844   0.1696   0.0030   0.0667   1.0000
        LTC8 |   0.0881  -0.0565   0.0641   0.1274  -0.0660   0.1719   0.0574   0.0600  -0.0981   0.1681   1.0000
        LTCG |   0.1404   0.1497   0.4547   0.3267   0.2797   0.2399   0.2936   0.2743   0.3993   0.3925   0.1481   1.0000
   FOFTOTAL |  -0.1836  -0.0428  -0.1461   0.0019  -0.1713  -0.0288  -0.0511  -0.1176  -0.0372  -0.1839  -0.0478  -0.2698   1.0000
  MEDTOTALR |   0.0496  -0.0044   0.1424  -0.0293   0.0726   0.1036   0.1060   0.1188   0.0536   0.0908   0.0746   0.1616  -0.0113   1.0000
       MED2 |  -0.0148   0.0049   0.2084   0.0675   0.1415   0.1205   0.0709  -0.0718   0.0777   0.0958   0.1027   0.1334  -0.0429   0.1141   1.0000
       MED1 |  -0.0183  -0.0728   0.1443   0.0728  -0.0377   0.1618   0.0748  -0.1008  -0.1251  -0.0591  -0.0179   0.0846  -0.0823   0.1954   0.2204
       MED3 |   0.0211  -0.0128   0.1711   0.1218   0.1374   0.5592   0.1284  -0.0117   0.1218   0.1964   0.1668   0.2195  -0.0710   0.1778   0.1725
       MED4 |   0.0722   0.0242   0.2121   0.0375   0.0387   0.0927   0.1545   0.0367   0.2044   0.0783  -0.0264   0.1765  -0.0514   0.4172   0.0903
     ACTIVE |   0.0984  -0.0042   0.1280  -0.0192   0.2078   0.0935   0.0214   0.0841  -0.0520   0.1380   0.2154   0.1485  -0.2817   0.2189   0.1774
     FLIGHT |  -0.1460  -0.1514  -0.1393  -0.1346  -0.1139   0.0633  -0.1759   0.0316  -0.0338   0.0394  -0.0093  -0.1065   0.1700  -0.0020  -0.1166
        FAR |   0.2062   0.1189   0.1871   0.0525   0.1911   0.0260   0.0766   0.0718   0.0812   0.1100   0.1513   0.2821  -0.3610   0.1560   0.0874
       SUP1 |   0.2679   0.1006   0.1289  -0.0412   0.1592  -0.0022   0.0275   0.0530   0.0216   0.2276   0.1308   0.1910  -0.4243   0.1516  -0.0500
      DRINK |  -0.2492  -0.1497  -0.0895   0.0085  -0.1061  -0.0052   0.1346  -0.0686  -0.0075  -0.0686  -0.0663  -0.0730   0.1298   0.0545  -0.0040
     JWR_1 |  -0.0585   0.0430   0.0209  -0.0582   0.0399  -0.1810   0.0033   0.0250  -0.0659   0.0391  -0.0998  -0.0377  -0.0419  -0.0590  -0.0988

             |     MED1     MED3     MED4   ACTIVE   FLIGHT      FAR     SUP1    DRINK    JWR_1
-------------+---------------------------------------------------------------------------------
        MED1 |   1.0000
        MED3 |   0.0953   1.0000
        MED4 |  -0.0151   0.1753   1.0000
      ACTIVE |   0.1026   0.1249   0.0854   1.0000
      FLIGHT |  -0.0211   0.0061  -0.0628  -0.1428   1.0000
         FAR |  -0.0240   0.0346   0.2040   0.4386  -0.2812   1.0000
        SUP1 |  -0.0511   0.0245   0.1290   0.2204  -0.0308   0.3037   1.0000
       DRINK |   0.0703   0.0021   0.0156  -0.1110   0.0345  -0.1993  -0.2157   1.0000
      JWR_1 |  -0.0910  -0.1640  -0.0511  -0.0436   0.0191   0.1381   0.0795  -0.0090   1.0000
```