FALL-RELATED BEHAVIOURAL RISK FACTORS

FALL-RELATED BEHAVIOURAL RISK FACTORS IN COMMUNITY-DWELLING OLDER ADULTS

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LAY ABSTRACT

Falling is very common for older adults. Falling can lead to injuries and long-term side effects like fear of falling. Community-based exercise programs are a cost-effective way to help large groups of older adults reduce their risk of falling. Exercise programs can reduce older adults' risk of falling by improving their balance and muscle strength. But exercise might not be enough to prevent falling in older adults. Falls can happen for various reasons, such as the activities or behaviours in which the individual participates. This thesis includes two studies presented in three papers aimed to better understand behavioural components which may be associated with falls. The results of this research suggest there is a psychological and social component involved with falling. The findings from this thesis highlight the importance of a holistic approach to and may help to inform the development of comprehensive interventions for fall prevention.

ABSTRACT

This thesis includes three manuscripts with an overarching objective to improve understanding of behavioural risk factors for falling in community-dwelling older adults.

The first manuscript presented in Chapter two, presents a protocol for a scoping review. The objective of this scoping review was to highlight the current methods used to identify fall-related risk-taking behaviours in community-dwelling older adults, and to identify factors that might contribute to these behaviours.

The second manuscript (Chapter three) presents the results of the scoping review written in the format for publication. The review identified older adults are generally aware of their own falls risk and engage in protective behaviours to reduce their risk of falling. Older adults engaged in risk-taking behaviours based on the potential benefits outweighing perceived risk of the behaviours. An individual's abilities, self-perception, personal values, and the environment likely influence the perception of risk which contributes to risk-taking behaviours.

The third manuscript (Chapter four) includes the analysis of clinical data from a community-based multi-component fall prevention program – the Building Balance Program. Individuals who participated in this six-week fall prevention program improved in balance ability, lower extremity muscle strength, mobility, and reduced fear of falling from baseline. Fear of falling (FoF) was the highest amongst the youngest participants despite having better physical function at the

outset of the Program. This suggests that in addition to physical function, other factors, like psychological and social factors may be involved with FoF.

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With the support of these incredible women, I was able to push myself to greater heights and advance myself into the clinician scientist I thrive to become.

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List of Abbreviations

BBP	Building Balance Program
BC	Balance confidence
BBS	Berg Balance Scale
CDC	Center for Disease Control and Prevention
CIHI	Canadian Institute for Health Information
FaB	Falls Behavioural Scale for Older People
FES-I	Fall Efficacy Scale – International
FoF	Fear of Falling
FR	Functional Reach
FrPCs	Fall-related psychological concerns
FsE	Fall-related self-efficacy
ICC	Intraclass correlation coefficient
IRR	Incidence rate ratios
JBI	Joanna Briggs Institute
OE	Fall-related outcome expectancy

OR	Odds Ratio
PHAC	Public Health Agency of Canada
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews
RaR	Rate ratio
RNAO	Registered Nurses' Association of Ontario
RR	Risk ratio
STEADI	Stopping Elderly Accidents, Deaths & Injuries
SUMARI	System for Unified Management, Assessment and Review of Information
TUG	Timed-Up and Go
WHO	World Health Organization
30 CST	30 second Chair Stand Test

List of Symbols

≥	Greater than or equal to
≤	Less than or equal to
>	Greater than
<	Less than

DECLARATION OF ACADEMIC ACHIEVEMENT

For each of the chapters included in this thesis, Diane Bégin conceptualized the purpose and research questions and, where applicable, led the collection and analysis of data and was responsible for writing and revising each chapter based on feedback.

Chapter two – Dr. Wojkowski and Dr. Richardson helped to refine the research question and conceptualization of risk-taking behaviours. Dr. Wojkowski, Dr. Richardson, Dr. Macedo, and Ashley Morgan, reviewed the objectives and design, and edited the manuscript.

Chapter three – Dr. Wojkowski provided guidance and expertise on scoping review methodology. Ashley Morgan and Jocelyne Labonté participated in the study review process and selection of studies included in the scoping review. Dr. Wojkowski, Dr. Richardson, Dr. Macedo, Ashley Morgan, Jocelyne Labonté all reviewed and refined the manuscript prepared for submission.

Chapter four – Dr. Wojkowski, Dr. Richardson, Dr. Macedo, all reviewed and refined the objectives and research questions, and provided feedback on the manuscript revisions. Dr. Macedo provided ongoing consultation on the statistical analysis. Dr. Macedo and Dr. Richardson also provided feedback on the organization of the data for presentation.

CHAPTER ONE: Introduction

1.1 Ageing and Geriatric Syndromes

Population ageing is a global phenomenon (World Health Organization (WHO), 2018). There are approximately 6.5 million Canadians who are ≥ 65 years (Statistics Canada, 2020). By 2036, the number of older adults is expected to increase to 10.4 million, representing 25% of the Canadian population (Sheets & Gallagher, 2013). Ageing is a natural, complex multifactorial process in all organisms (Khan et al., 2017; Nigam et al., 2012). At the biological level, ageing is characterized by the progressive degeneration of cell, tissue, and organ function (Khan et al., 2017; Nigam et al., 2012). These degenerative changes lead to gradual decreases in physical and mental capacity, increased risk of chronic disease, and eventually, death (Khan et al., 2017; Nigam et al., 2012; WHO, 2018). Although ageing is a time-dependent process determined mainly by genetics, it is also influenced by behavioural and environmental factors (Khan et al., 2017; Nigam et al., 2012). As a result, the trajectories of age-related decline may vary from person to person (Khan et al., 2017; Nigam et al., 2012; WHO, 2018).

A geriatric syndrome is a non-disease clinical condition that occurs with biological ageing (Inouye et al., 2007; Olde Rikkert et al., 2003; Tinetti et al., 1995; WHO, 2018). Geriatric syndromes are characterized by multiple etiological and interacting pathogenic pathways that involve multiple organ systems to produce a single symptom or fixed combination of symptoms (Inouye et al., 2007; Olde Rikkert et al., 2003; Tinetti et al., 1995). Common geriatric syndromes include falls, delirium, frailty, dizziness, syncope, and urinary incontinence (Inouye et al., 2007; Olde Rikkert et al., 2003; Tinetti et al., 1995; WHO, 2018). Although each geriatric syndrome is distinct, previous research has demonstrated shared multiple risk factors across different geriatric syndromes (Damluji et al., 2020; Inouye et al., 2007; Lee et al., 2009; Olde Rikkert et al., 2003; Tinetti et al., 1995; Vaughan et al., 2018). For example, lower and upper extremity weakness, decreased vision and hearing, and either anxiety or depression have been identified as independent predisposing factors for incontinence, falls, and/or functional dependence (Tinetti et al., 1995).

1.2 Impact of Falls on the Older Adult

With approximately one in three older adults falling each year, falls are among the most common geriatric syndromes. A fall is defined as "an unexpected event in which participants come to rest on the ground, floor or lower level" (Lamb et al., 2005, p. 1619). In Canada, an estimated 20-30% of community-dwelling adults ≥ 65 years, and 50% of those ≥ 85 years experience at least one fall annually (Medical Advisory Secretariat, 2008; Public Health Agency of Canada (PHAC), 2014; Scott et al., 2011). Experiencing a fall in older age can result in physical and psychological consequences, ranging from mild to severe (Terroso et al., 2014). Acute physical consequences include fractures, head trauma, abrasions, lacerations, joint and soft tissue injuries (Terroso et al., 2014). Falls are the leading cause of injury-related hospitalizations among Canadian older adults. (PHAC, 2014; Scott et al., 2011). The direct costs of falls in Canada are an estimated $8.7 billion per year (Registered Nurses' Association of Ontario (RNAO), 2017). In 2017/18, 112,008 Canadian older adults (≥ 65 years) were hospitalized for a fall-related injury, a 9% increase from 2014-2017 (Canadian Institute for Health Information (CIHI), 2019). The average length of stay for Canadian older adults hospitalized for fall-related injuries in 2010/11 was 22 days, exceeding the average length of stay for all other causes of hospitalization by approximately 70% (PHAC, 2014; Scott et al., 2011). According to the PHAC (2014), over one-third of older adults hospitalized due to fall-related injuries are discharged to long-term care facilities. As the burden and prevalence of falls continues to increase with the ageing population, researchers need to carry on with investigating fall risk factors and fall prevention initiatives.

1.3 Fall Risk Factors

The risk of falling in older adults is complex and multifactorial (PHAC, 2014; WHO, 2007). Most falls occur when the accumulated effects of impairments combined with situational challenges overwhelm an individual's ability to maintain or regain balance (Feldman & Chaudhury, 2008; PHAC, 2014; RNAO, 2017; WHO, 2007). Over 400 risk factors for falls have been identified and every individual faces a unique combination of factors which put them at risk for falls (PHAC, 2014; RNAO, 2017; WHO, 2007). The WHO's *Risk Factor Model for Falls in Older Age* (Figure 1) classifies fall risk factors into four dimensions:

(i) *Biological Risk Factors,* (ii) *Behavioural Risk Factors,* (iii) *Environmental Risk Factors, (iv) Socioeconomic Risk Factors* (WHO, 2007). Each of these dimensions is explored in more detail below.

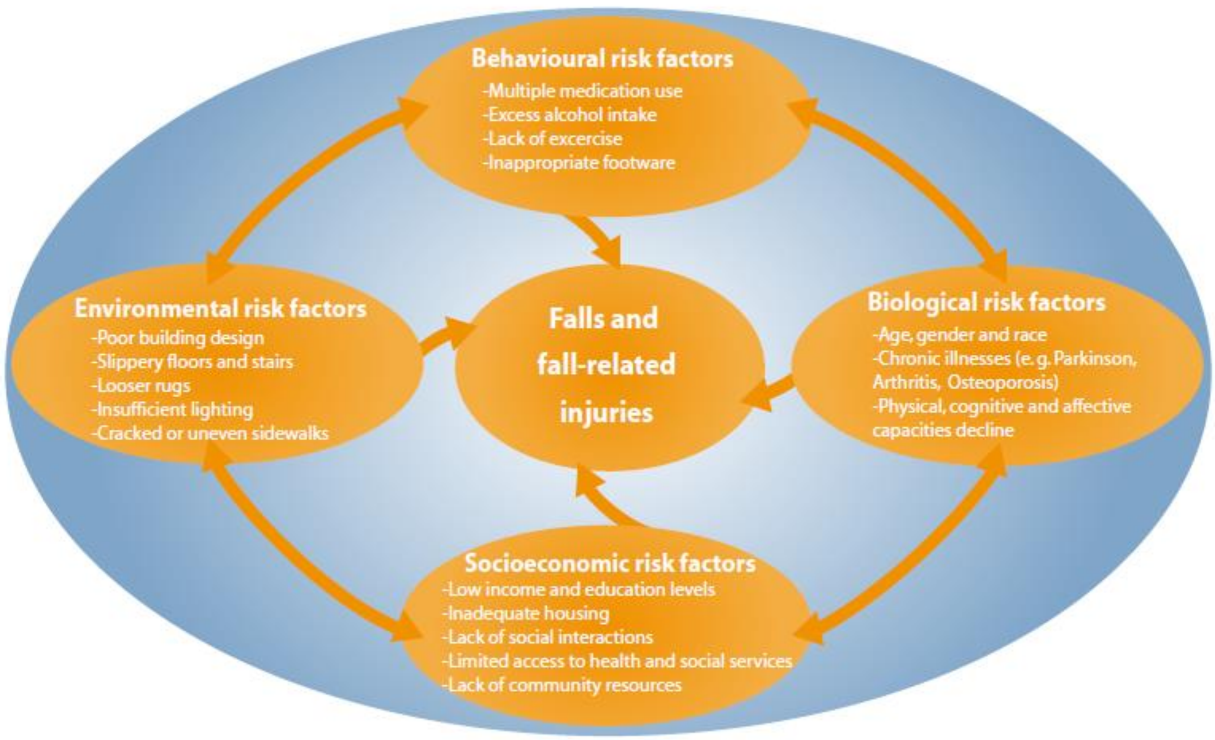

Figure 1. WHO Risk Factor Model for Falls in Older Age (WHO, 2007); Reproduced with permission

1.3.1 Biological Risk Factors

Biological risk factors are "characteristics of individuals that pertain to the human body" (WHO, 2007, p. 5). These include non-modifiable risk factors, such as age and sex, and modifiable risk factors, such as impaired mobility, balance deficits, and muscle weakness (WHO, 2007). Studies identified a greater prevalence of falls and fall-related injuries in women than men (Chang & Do, 2015; Deandrea et al., 2010; Duckham et al., 2013; Peel, 2011; Stevens & Sogolow, 2005). A secondary analysis of the Canadian Community Health Survey (CCHS) – Healthy Aging survey (Statistics Canada, 2010) found the prevalence of falls and fall-related injuries were 1.3 times and 2.6 times greater in women compared to men, respectively (Chang & Do, 2015). There are a few possible explanations as to why women are at an increased risk of falling compared to men. Although age-related muscle loss affects both women and men, differences at the histological level (e.g., muscle fiber atrophy) have been identified between males and females (Roberts et al., 2018). Historically, women have also faced numerous barriers to participation in sport and strength training which can have an effect on an individual’s functional reserve prior to experiencing age-related muscular changes (Shurley et al., 2020). This means both physiological and sociological factors likely contribute to the observed strength differences in older adult males and females.

Chronic conditions and multi-morbidity are also highly associated with fall incidence (Lee et al., 2009; Sibley et al., 2014; Vetrano et al., 2016). Linear trends between the prevalence of falling and the number of chronic conditions have been identified, which suggest an additive effect of chronic disease on fall risk (Lawlor et al., 2003; Lee et al., 2009; Shumway-Cook et al., 2009; Sibley et al., 2014). Physiological changes associated with chronic conditions often result in physical limitations that can increase an individual's fall risk (PHAC, 2014; WHO, 2007). For example, diabetic peripheral neuropathy affects lower extremity sensation, leading to balance and gait impairments (Mustapa et al., 2016). In addition, medications used to manage chronic conditions, such as antidepressants, have been associated with an increased fall risk as older adults are often more susceptible to adverse effects of drugs (Ming & Zecevic, 2018; Park et al., 2015; Zia et al., 2015).

Reduced muscle strength, decreased mobility, and balance and gait impairments are amongst the most important risk factors for falls (PHAC, 2014; RNAO, 2017; WHO, 2007). Moreland et al., (2004) found lower extremity weakness to be strongly associated with falls (odds ratio (OR) = 1.76, 95% CI = 1.31 to 2.37) and recurrent falls (OR = 3.06, 95% CI = 1.86 to 5.04). Slower walking speeds and increased gait variability (e.g., stride frequency, stride length, and center-of-mass lateral sway) are common gait characteristic observed in individuals with a history of falls (Barak et al., 2006; Brach et al., 2005; Callisaya et al., 2011; Hausdorff et al., 2001; Lusardi et al., 2017). Muir et al. (2010) found balance impairments in community-dwelling older adults were also associated with falls (OR 1.98, 95% CI = 1.60 to 2.46).

Biological characteristics of older adults are amongst the most important risk factors for clinicians to address in fall prevention programs (PHAC, 2014; RNAO, 2017; WHO, 2007). Advanced biological age, female sex, chronic conditions and multimorbidity, have been associated with decreased physical function (PHAC, 2014; RNAO, 2017; WHO, 2007). Muscular weakness and balance impairments likely reduce an individual’s ability to overcome situational challenges, thus increasing their risk of falling.

1.3.2 Behavioural Risk Factors

Behavioural risk factors for falls are defined as "human actions, emotions, or daily choices" (WHO, 2007, p.5). The PHAC (2014) describes behaviours as risk-taking when an individual's abilities do not meet the demands of the activity. However, this characterization may oversimplify risk-taking behaviours and warrants further investigation. Risk factors for falls include risk-taking behaviours, alcohol abuse, dietary intake, footwear and clothing, and fall-related psychological concerns (WHO, 2007). For example, alcohol consumption may increase an individual's risk of falling by adversely affecting gait, balance, and cognition (PHAC, 2014). A cross-sectional study of 615 fall-related emergency room admissions identified 31.2% of males and 16.7% of females > 50 years had consumed alcohol at the time of their fall (Kurzthaler et al., 2005). Poor dietary habits are also associated with reduced physical function and lean muscle mass, which can in turn increase an individual's fall risk (Scott et al., 2010; Smee et al., 2015; Zhao et al., 2020).

Appropriate footwear that features thin, hard, slip-resistant soled shoes with a low heel height can reduce an older adult's fall risk by optimizing foot position and stability and surface friction (Maden et al., 2021; Menant et al., 2008). Petersen et al., (2020) identified minimalist shoes were associated with increased local dynamic stability (p = 0.013, partial η^2 = 0.10) and decreased minimal toe clearance variability (p = 0.018, partial η^2 = 0.09), when compared to barefoot conditions. Slippers, defined as “a type of light, soft shoe, easily put on and taken off” (p. 14), were the most common type of footwear worn at the time of a fall (Davis et al., 2019). However, the evidence to support associations between falls and other types of footwear (e.g., high heels) is limited. Specifically, there are only a few studies available, which provide low quality evidence (Davis et al., 2019). Evaluating the association between footwear style and falls can be challenging as there is high variability of shoe characteristics within each style. For example, high heel shoes vary in heel height (e.g., 3cm, vs 6cm lift) and heel type (e.g., thick heel vs thin heel), and both components have been shown to affect lower extremity biomechanics, postural stability, and gait characteristics (Shang et al., 2020). Shoes can also vary in weight, which could affect falls risk – heavier shoes may lead to lower foot clearance during the swing phase in individuals with weakness in hip flexor and ankle dorsiflexion strength, increasing their risk of tripping.

Fall-related psychological concerns (FrPCs) refer to a group of four distinct constructs: fear of falling (FoF) (Tinetti & Speechley, 1989), fall-related self-efficacy (Tinetti et al., 1990), balance confidence (Myers et al., 1996) and fall-related outcome expectancy (Yardley & Kempen, 2006; Yardley & Smith, 2002) (Hughes et al., 2015; Moore & Ellis, 2008). Although FrPCs refer to four distinct constructs, these constructs have been used interchangeably in falls literature

(Hadjistavropoulos et al., 2011; Hughes et al., 2015; Moore & Ellis, 2008). Researchers have advocated for studies to explore each FrPCs as distinct constructs, as each construct has different theoretical underpinnings. For example, fear is a normal emotional and physiological response to an active or imagined threat (Bhala et al., 1982); whereas self-efficacy refers to an individual's perception of abilities within a particular domain of activities (Tinetti et al., 1990). However, measures of FrPCs continue to be used interchangeably with measures of self-efficacy when evaluating prevalence, risk factors and prevention of FoF (Kendrick et al., 2015; Schoene et al., 2019; Whipple et al., 2018). For example, many studies use measures of fall efficacy, such as the Tinetti Fall Efficacy Scale, to measure of FoF (Schoene et al., 2019). This likely impacts our understanding of the psychological impact of falls. For instance, reports on the prevalence of FoF range between 20% to 85% in community-dwelling older adults - regardless of fall history (Jørstad et al., 2005; Scheffer et al., 2008; Schoene et al., 2019). This large range is observed as studies have used various measures of FrPCs to evaluate the prevalence of FoF. Future research should aim to study these concepts independently to broaden our understanding of FrPCs, as each concept is likely to have their own risk factors. This work will ultimately improve our understanding of effective interventions for each FrPCs construct.

1.3.3 Environmental Risk Factors

Environmental risk factors are "…the interplay of the individual's physical conditions and the surrounding environment, including home hazards and hazardous features in public environments" (WHO, 2007, p. 5). In other words, environmental risk factors themselves do not cause falls, instead falls result from the interaction between environmental stressors, an individual's behaviour, and physical condition (WHO, 2007). Approximately 50% of falls occur inside an older adult's home (CIHI, 2019; PHAC, 2014). Environmental hazards are commonly found in the homes of older adults (Carter et al., 1997; Gill et al., 1999; Leclerc et al., 2010). Leclerc et al., (2010) found 90.8% of community-dwelling older adults living in a semi-rural region of Quebec had at least one environmental hazard in their homes, with an average of 3.3 hazards per home. Common home hazards include dim lighting; the presence of throw rugs, runners, or mats; electrical cords in walkways; raised door sills; cluttered or slippery floors; poorly designed tubs, toilets, and fixtures in the bathroom; absence of handrails on stairs; incorrect bed, chair, couch height (Carter et al., 1997; Gill et al., 1999; Leclerc et al., 2010; PHAC, 2014).

Hazardous features in the public environment such as stairs and building designs, footpath quality (e.g., uneven pavement), lack of curb ramps and rest areas may also increase the risk of a fall (Chippendale & Boltz, 2015; Kamp et al., 2014; Li et al., 2006; PHAC, 2014). A community-based case-control study of 2193 adults (≥ 45 years) found that the majority of outdoor falls were associated with the presence of one or more environmental hazards (e.g., cracks in the sidewalk) (Li et al., 2006). The presence of environmental hazards in neighbourhoods is also commonly cited by older adults as barriers to physical activity (Chippendale & Boltz, 2015; Dawson et al., 2007; Eronen et al., 2014). Older adults who reported more than one environmental hazard in their neighbourhood had reduced levels of walking in the preceding week ($Z = -2.25$, $p = 0.019$) compared to those who reported no barriers (Dawson et al., 2007). Weather and climate conditions may also create barriers to safe access to roadways, sidewalks, and buildings (PHAC, 2014); for example snow and ice can reduce underfoot traction, therefore increasing the risk of slips and falls (Abeysekera & Gao, 2001; Gao & Abeysekera, 2004).

1.3.4 Socioeconomic Risk Factors

Socioeconomic risk factors concern social and economic factors that expose individuals to conditions associated with increased risk of falling (PHAC, 2014; WHO, 2007). Seniors living in subsidized housing buildings in Hamilton, Ontario, reported issues with pain or discomfort (75.2%), mobility (63.7%), anxiety or depression (47.5%), difficulties performing usual activities (45.6%) (Agarwal et al., 2018). They also demonstrated poor functional health literacy levels (82.1%) (Agarwal et al., 2018). Older adults living in public housing across Ontario also reported having mobility issues (51.0%), anxiety or depression (47.9%), reduced physical activity (40.0% exercised < 30 mins/day), and poor diet (34.4% consumed < 1 serving of fruits and vegetables per day) (Pirrie et al., 2020).

Social isolation and loneliness are highly prevalent among community-dwelling older adults and are associated with numerous negative health outcomes, including falls (Petersen et al., 2020). Quach et al. (2020) observed an increased falls risk in older adults with a perceived lack of social support and loneliness (incidence rate ratios (IRR) = 1.34, 95% CI = 1.12 to 1.60). A three-year prospective study of 9,704 women > 65 years showed a positive association between stronger family relationships and decreased falls risk (risk ratio (RR) = 0.87, 95% CI = 0.78 to 0.98) (Faulkner et al., 2003). Although it is unclear through which mechanisms social connectedness reduces falls risk, the findings from these studies are consistent with the social convoy model (Antonucci et al., 2014). The social convoy model posits that individuals form social relationships with others throughout the life course (Antonucci et al., 2014). These relationships can vary in closeness, structure, function, and quality (Antonucci et al., 2014). Faulkner et al., (2003) noted stronger family relationships (closeness) may reduce falls risk by providing physical assistance and expressing concerns about hazardous activities (function). However, other evidence suggests when family members express concerns about hazardous activities, this may result in an increase in the frequency with which the behaviour occurs (Kilian et al., 2008; Pohl et al., 2015). Future research should explore the mechanisms in which closeness, structure, function, and quality of social relationships influence fall risk in community-dwelling older adults.

1.4 Fall Risk Assessments

As the risk of falls is complex and situationally specific, identifying individuals and groups of community-dwelling older adults at risk of falling can be challenging. The Center for Disease Control and Prevention (CDC) developed the Stopping Elderly Accidents, Deaths & Injuries (STEADI) toolkit and algorithm to facilitate multifactorial fall risk screening and prevention efforts in primary care (CDC, 2019; Stevens & Phelan, 2013). The STEADI toolkit and algorithm is a comprehensive resource for healthcare providers that have been implemented in primary care across the United States (CDC, 2019; Sarmiento & Lee, 2017; Stevens & Phelan, 2013). This toolkit includes an algorithm based on the American Geriatric Society/British Geriatric Society clinical practice guidelines (Drootin, 2011); three fact sheets on fall risk factors and medications associated with falls; case studies illustrating profile of individuals with low, moderate, and high fall risk; guidelines and example of conversations with patients on fall prevention; standardized instructions for measuring orthostatic blood pressure; three performance-based assessments; referral forms; recommended fall prevention programs; and patient education materials (Stevens & Phelan, 2013). The STEADI toolkit is accessible online at no-cost (Sarmiento & Lee, 2017). The CDC recommends healthcare providers use the STEADI algorithm to screen for fall risk annually or anytime following a fall (CDC, 2019). Fall screening tools are short tests intended to determine whether an older adult is at risk of falling but are not used to determine interventions (Lamb et al., 2011). A positive fall risk screen should be followed by a comprehensive, multifactorial fall risk assessment to identify modifiable risk factors for intervention (CDC, 2019). The assessment may include gait, strength, and balance testing; medication review; home hazard evaluation; physical and cognitive exam; visual acuity check; nutrition/diet assessment; and feet/footwear assessment (CDC, 2019). The STEADI algorithm provides primary care providers a systematic approach for fall risk screening in community-dwelling older adults; however, the algorithm lacks direction regarding multifactorial fall risk assessment. As there are a number of risk factors to consider, it can be challenging for healthcare providers to determine which risk factors to assess. Multiple referrals or collaborations of an interprofessional healthcare team may be required to fully assess an individual's risk of falling. However, multiple referrals and interventions delivered at once may overwhelm an individual which could lead to low adherence. In addition, cost of services associated with multiple referrals may be a barrier for individuals and healthcare systems. Further research should assess the effectiveness, adherence, and cost-effectiveness of a stepwise referral process compared to multiple referrals delivered at once for older adults who have experienced or who are at risk of a fall.

1.5 Fall Prevention

Fall prevention interventions vary in terms of the number of risk factors targeted and the delivery of the intervention (e.g., individually tailored compared to community programs) (Lamb et al., 2011). To improve reporting of fall prevention interventions, Lamb et al., (2011) proposed a taxonomy according to the combination of intervention sub-domains. These sub-domains consist of exercise, medication (drug target), surgery, management of urinary incontinence, fluid or nutrition therapy, psychological, environmental/assistive technology, social environment, and others. A single combination approach to fall prevention focuses on one intervention sub-domain with participants. Multiple combination interventions are commonly used in community-based fall prevention programs and typically consist of exercise combined with at least one additional sub-domain. Multifactorial fall prevention programs involve two or more intervention sub-domains specifically tailored to an individual's fall risk profile (Lamb et al., 2011). Lamb et al.'s, (2011) taxonomy provides researchers and clinicians with a good starting point to classify fall prevention programs; however, interventions within the same sub-domain can contain different components which can lead to different outcomes (Craig et al., 2008). For example, exercise can vary in terms of frequency (e.g., 3x/week), training intensity (e.g., heart rate), exercise type (e.g., strength, power, flexibility, cardio), and timing (e.g., rest periods). Therefore, it is important researchers and clinicians describe these characteristics in detail to allow the reproducibility of the intervention. Additionally, the use of the taxonomy cannot replace the use of clinical reasoning, and client centered care. As such, researchers and clinicians must design interventions that are reflective of each client's unique needs which are identified with a thorough assessment.

1.5.1 Single Combination Approach to Fall Prevention

Exercise-based interventions are the most common form of single combination fall prevention interventions (Kendrick et al., 2015; Sherrington, et al., 2019). Interventions such as the Otago Exercise Program (Campbell & Robertson, 2003) have demonstrated positive effects on pain (Cederbom & Arkkukangas, 2019), balance and mobility (Martins et al., 2018), fear of falling (Mat et al., 2017), fall rates, and mortality (Thomas et al., 2010). A systematic review by Sherrington et al., (2019) identified 108 exercise-based fall prevention interventions from community-dwelling older adults. Amongst these interventions, 52% were delivered in a group setting, 29% were delivered individually, and 18% involved a combination of group and individual exercise (Sherrington et al., 2019). Overall, exercise-based interventions reduced the rate of falls by 23% (rate ratio (RaR) 0.77, 95% CI = 0.71 to 0.83; 12, 981 participants, 59 studies; high-quality evidence) compared to the control groups (e.g., usual care) (Sherrington, et al., 2019). Exercise interventions that consisted of balance and resistance training reduced rate of falls by 34% (RaR 0.66, 95% CI 0.50 to 0.88; 1374 participants, 11 studies; moderate-quality evidence, I^2 = 65%) (Sherrington et al., 2019). Balance and resistance training interventions are likely more effective than general exercise (e.g., tai chi) as these interventions directly address muscles weakness, and balance impairments, which are amongst the most important risk factors for falls. Although interventions that consist of balance and resistance training are more effective at reducing falls than general exercise, clinicians should consider the client's preference when considering which type of exercise to use. For example, interventions such as Tai Chi may be culturally meaningful to some clients (Lu, 2018).

Evidence to support other sub-domains as single interventions for fall prevention is limited, as they are typically combined with exercise programs. For instance, the CDC recommends individuals who are not identified as at risk for falls after screening should still receive education on fall prevention, be assessed for vitamin D intake, and be referred to a community exercise or fall prevention program (CDC, 2019). Wu & Pang (2017) completed a meta-analysis of vitamin D combined with calcium supplementation found a small reduction in the risk of having at least one fall (OR = 0.87, 95% CI = 0.80 to 0.94; I^2 = 46%) compared to the placebo groups.

1.5.2 Multiple Combination Approach to Fall Prevention

A systematic review by Goodwin et al., (2014) demonstrated a significant reduction in number of older adults who fall (RR = 0.85, 95% CI = 0.80 to 0.91) and fall rate (RaR = 0.80, 95% CI = 0.73 to 0.88) following participation in a multiple combination intervention compared to control groups (i.e., no intervention, usual care, or placebo). Of the 14 studies included in this review, 12 incorporated exercise combined with environment and assistive technology (n = 5), knowledge/education (n = 4), psychological interventions (n = 4), medication review (n = 3), fluid or nutritional supplementation (n = 2), and/or continence management (n = 1) (Goodwin et al., 2014).

1.5.3 Multifactorial Combination Approach to Fall Prevention

Like multiple combination interventions, multifactorial interventions include two or more intervention sub-domains (Lamb et al., 2011). However, the intervention sub-domains are specific to an individual's fall risk profile (Lamb et al., 2011). Hopewell et al.'s, (2019) systematic review found multifactorial interventions slightly reduced the risk of one or more falls compared to usual care with moderate-quality evidence (RR = 0.95, 95% CI 0.90 to 1.00). Multifactorial interventions often rely on referral of participants to healthcare providers or existing community programs (Tinetti, 2008). These programs may be ineffective at reducing falls due to poor adherence (Tinetti, 2008). For example, a randomized controlled trial by Milolaizak et al., (2017) found 54% of participants who were referred to other healthcare providers did not adhere to fall-prevention recommendations. Amongst the non-adherers, 21% of participants declined a referral to physical therapy; 38% of participants declined a referral to occupational therapy; 87% declined a referral to a specialty clinic for falls, balance, and bone health; and 16% declined a referral to an optometrist. Multivariate analyses found positive attitudes towards fall prevention (OR 4.10, 95% CI 1.48 to 11.39) and three or more fall prevention recommendations (OR 3.36, 95% CI 1.26 to 9.00) predicted intervention adherence to the recommendations (Milolaizak et al., 2017). However, both predictors in this study have large confidence intervals, which indicates further investigation is needed to determine predictors of adherence to multifactorial fall prevention interventions.

When evaluating the effectiveness of the multifactorial program, Milolaizak et al., (2017) considered ‘partial adherers’ (e.g., reported exercising sometimes) as ‘non-adherers’. Non-adherers had greater fall rates (3.15 falls per person year) compared to adherers (2.06 falls per person year; incidence rate ratio 0.53, 95% CI 0.45-0.80). This highlights the importance of adherence when considering the effectiveness of an intervention. Tinetti (2008) also highlighted that multifactorial fall prevention approaches that rely on referrals may be ineffective due to lack of available guidelines for health care providers. Thus, to improve multifactorial fall prevention initiatives, researcher should focus on developing clinical guidelines to inform clinicians on effective fall prevention interventions. Researchers should also provide training to healthcare practitioners and community program staff on developing community-based fall prevention programs (Tinetti, 2008).

1.6 Summary

Numerous assessments, screening tools, and complex interventions with various approaches have been developed to reduce the rate of falls and fall-related injuries. Community-based exercise interventions may be a good starting point for fall prevention, as they are accessible and cost-effective options for reaching large proportions of the population (Page et al., 2012). The evidence to support exercise as a fall prevention intervention is consistent with the notion that increasing an individual's functional capacity would decrease their vulnerability to situational challenges that may cause a fall. While this approach may reduce the rate of falls and fall-related injuries, it may not fully address an individual’s fall risk profile (Tinetti, 2008).

Although the evidence to support multifactorial interventions is limited, these interventions may be necessary for some individuals with complex fall risk profiles (Campbell & Robertson, 2007). For example, an older adult may present with multi-morbidities, polypharmacy, reduced physical functioning, numerous home hazards, fear of falling, and poor dietary habits will likely need a medication review, a home assessment and modification, change in dietary habits, and an exercise intervention. However, delivering all interventions at once may be unnecessary, and overwhelming for the individual (Campbell & Robertson, 2007). In addition, there may be interactions amongst intervention components (Campbell & Robertson, 2007). For example, progressive balance training may improve an individual’s balance and balance confidence.

As there has been little investigation on the association between biological, environmental, and behavioural risk factors it is unclear how healthcare providers should approach multifactorial fall prevention. Identifying relationships between biological, behavioural, and environmental risk factors may provide valuable information needed in the decision-making process to determine which interventions are best suited for an individual. For example, progressive balance training may not suffice for an individual who has a fear of falling that is influenced by depressive symptoms.

1.7 Thesis Objectives

The overall objective of this thesis is to explore relationships between behavioural risk factors, physical capacity, and falls in community-dwelling older adults. This was achieved through the completion of two research studies. The specific objective of the first study (Chapters two and three) was to explore fall-related risk-taking behaviours from a variety of perspectives. Using a scoping review methodology, this first study identified risk-taking behaviours and factors associated with risk-taking in community-dwelling older adults (≥ 65 years). The primary objective of the second study (Chapter four) was to determine whether participants' level of FoF, balance, gait, and lower extremity strength improved following participation in a community-based multi-component fall prevention program. Its secondary objective was to explore the relationships between FoF and balance, gait, and lower extremity strength in older adults.

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CHAPTER TWO

RISK-TAKING BEHAVIOURS AND FALLS IN COMMUNITY-DWELLING OLDER ADULTS: A SCOPING REVIEW PROTOCOL

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Risk-taking behaviours and falls in community-dwelling older adults: a scoping review protocol

ABSTRACT

Objective: The objectives of this proposed scoping review are to systematically identify the risk-taking behaviours in community-dwelling older adults as well as the methods used to identify these behaviours. This review explores predisposing factors to fall-related, risk-taking behaviours in community-dwelling older adults

Introduction: Most falls occur as a result of complex interactions between fall risk factors. Research has identified the role of mobility and environmental factors in falls, however, little is known about the role of risk-taking behaviours on falls.

Inclusion criteria: Studies that explore fall-related, risk-taking behaviours in community-dwelling older adults (≥ 65 years) will be included for this review. Only studies published in the year 2000 and onwards will be considered for inclusion.

Methods: A comprehensive literature search will be completed in Ovid AMED, Ovid Embase, Ovid MEDLINE, Ovid PsycINFO, EBSCOhost CINAHL, and EBSCOhost AgeLine. Studies published in English and French will be considered for inclusion. Two reviewers will independently screen titles and abstracts to identify studies for full review. The full texts will then be independently reviewed by the same reviewers to assess eligibility, with a third reviewer available to resolve disagreements. A data extraction tool will be used to extract the data from the studies that meet full eligibility criteria. Data extracted from the texts will be synthesized and reported in table format accompanied by a narrative summary that will connect the results the objective of the scoping review.

Keywords: community-dwelling; falls; older adults; risk-taking behaviours

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INTRODUCTION

Falls are a major global public health concern in older adults. Globally, it is estimated that one in three older adults fall each year, with rates of hospital admission ranging from 1.6 to 8.9 per 10,000 population.[1] With a global aging population, fall-related injuries are projected to double by 2036, exacerbating the public health impact of falls.[1] Falls, with or without injury, can also result in social, psychological, and economic consequences to the individual and their family.[2–4]

Falls, are recognized as a complex multifactorial phenomenon. Feldman and Chadhury[5] proposed a three-dimensional conceptual framework to describe the complex interaction of risk factors and falls. This framework proposes that a person's fall risk is dependent on their ability to move about, the surrounding environmental conditions, and the behaviours they choose to engage in.[5] For example, an older adult with limited mobility may have to take extra precautions and only engage in activities in safe environments (flat, non-slip surfaces) to reduce their fall risk.

Mobility is defined as "the ability to move oneself (either independently or by using assistive devices or transportation) within a variety of environments."[6(p.444)] A systematic review (SR) and meta-analysis linking balance deficits to falls in community-dwelling older adults demonstrated balance impairments resulting in moderate fall risk (risk ratio of 1.42, 95% CI 1.08-1.85).[7] A further SR and meta-analysis of exercise-based fall prevention interventions compared the effectiveness of 81 exercise interventions with usual care on reducing the number of falls in community-dwelling older adults.[8] Overall, any exercise type reduced the rate of falls over time by 23%.[8] Exercise interventions, which included balance, functional, and resistance exercises, had the greatest effect size, reducing fall rates by 34%.[8] Although the evidence from these studies is promising, other factors likely contribute to the incidence of falls.

Environmental risk factors may be regarded as the physical environment surrounding an individual. These include factors such a building design, condition and types of surfaces, presence of objects and/or hazards, the design of outdoor spaces, lighting, as well as weather conditions.[5,9] A narrative review that examined the relationship between environmental hazards and falls in older adults found no clear association between the two factors.[5] A further SR of cross-sectional and cohort studies also examined the magnitude of the physical environment as a risk factor for falls.[9] The authors found the physical environment presented an overall non-significant risk for falls (odds ratio of 1.15, 95% CI 0.97, 1.36).[9] The results from these environmental studies suggests that risk factors other than the physical environment are likely associated with falls.

Risks are a characteristic of decisions, defined as “the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized.”[10(p.10)] Risks are present in all aspects of daily life, and it would be impossible for an individual to avoid all risks.[11] Behaviour is most often defined as “any observable movement of the organism generally taken to include verbal behaviour as well as physical movements."[12(p.147)] As such, risk-taking behaviour may be regarded as engaging in any observable movement associated with a degree of uncertainty about the outcomes of the behaviour.[11,13–15] The breadth of this definition implies a wide range of behaviours can qualify as risk-taking behaviours, which can be a challenge for the operationalization of risk-taking behaviours.[11,15,16] Risk-taking behaviours are often identified by: i) an observed behaviour, where researchers observe participants engaging in activities; ii) a self-reported behaviour, where participants recall risk-taking behaviours; or iii) a hypothetical choice, where participants are asked to choose between two imaginary options.[11]

Older adults must adjust their perceived abilities to accommodate for age-related changes.[17] Misjudgments between perceived and actual abilities may then influence risk-taking behaviours, as the individual may engage in behaviours outside of their capabilities.[17] There are several strategies available to lower one's risk, such as asking for help to perform higher-risk tasks, like standing on a stool to hang a curtain.[2] However, many older adults have expressed that these strategies to avoid risk often interfere with their independence,[2–4] and these individuals often deliberately act against safe practices in order to maintain their sense of independence.[2–4] A qualitative study examining risk-taking behaviours in hospitalized older adults found persons who took risks were deliberately testing their boundaries, which was motivated by factors such as a "desire to be independent."[4]

Risk-taking behaviours are individual-specific as they are relative to the individual's physical abilities and the surrounding environment.[5,18] For example, stepping up on a stool to hang a curtain may be a low-risk activity for an individual with good strength and balance, however, for an individual with poor strength and balance this may be considered a high-risk activity. Several factors have been postulated to influence risk-taking behaviours, such as culture, attitudes, emotions, coercion, the environment, and perceptions of physical abilities.(Boyer, 2006; Feldman & Chaudhury, 2008; Little & Wyver, 2010) McLeroy and colleague's social ecological model of health proposes five levels of influence for health behaviours: i) intrapersonal factors, ii) interpersonal factors, iii) institutional factors, iv) community factors, and v) public policy.[18] Intrapersonal factors reflect on the characteristics of the individual, such as knowledge, attitudes, and self-perception.[18] Interpersonal factors concern the social networks and support systems of the individual.[18] Institutional factors relate to the rules and regulations for an organization.[18] Community factors regard the relationships among organizations within a defined boundary.[18] Public policy refers to the laws and policies at all system levels (municipal, provincial, federal).[18]

Despite being recognized as an important fall risk factor, evidence on risk-taking behaviours and falls in community-dwelling older adults is limited. Given the paucity of evidence, a scoping review will be utilized to determine the extent and nature of research on fall-related, risk-taking behaviours and falls in community-dwelling older adults.[19] A preliminary search of PROSPERO, MEDLINE, the

Cochrane Database of Systematic Reviews, and *JBI Evidence Synthesis* was conducted and no current or in-progress scoping or systematic reviews on the topic were identified.

The purpose of this scoping review is to develop an understanding of risk-taking behaviours from a variety of perspectives by systematically identifying fall-related, risk-taking behaviours and the approaches used to identify (e.g., self-reported behaviours) these behaviours in the literature. This scoping review also intends to map out factors that influence fall-related, risk-taking behaviours in community-dwelling older adults (e.g., individual's perception of abilities). The information from this scoping review will provide a framework to guide future primary research on fall-related, risk-taking behaviours in community-dwelling older adults.

Review Questions

i. What risk-taking behaviours have been identified as risk factors for falls in community-dwelling older adults?

ii. What types of assessments are used to identify risk-taking behaviours for falls in community-dwelling older adults?

iii. What predisposing factors influence fall-related, risk-taking behaviours in community-dwelling older adults?

Inclusion criteria

Participants

This review will consider studies that discuss risk-taking behaviours related to falls in older adults living independently in the community. Studies will be included if participants are 65 years and older.

Concept

The concept that will be studied is risk-taking behaviour related to falls. All studies that identify, describe, and/or evaluate fall-related, risk-taking behaviours will be included regardless of who identifies the risk. This includes studies that evaluate the circumstance/situations of falls, as these studies identify the behaviours preceding a fall.

Context

This review will consider studies conducted in a research laboratory and community-based settings. Studies conducted in hospital settings will be included if the study discusses risk-taking in community-based settings (ie, a patient was admitted for fall-related injuries and reports details on behaviour leading to the fall). Studies conducted in settings where 24-hour medical support is provided (eg, nursing homes) will be excluded due to the significant health challenges and potential cognitive impairments present in these populations.

Types of sources

Experimental and quasi-experimental study designs including randomized controlled trials, non-randomized controlled trials, before and after studies, and interrupted time-series will be considered for inclusion. This scoping review will also consider observational studies such as case-control studies, case series, case reports, prospective and retrospective cohort studies, and cross-sectional studies. Qualitative study designs will also be considered for inclusion. This includes, but is not limited to, designs such as phenomenology, ethnography, qualitative description, grounded theory, action research, and feminist research. Review papers will also be considered to identify original studies. The reference list of eligible review papers will be scrutinized by the two reviewers to identify additional studies for review. Text, opinion papers, and gray literature will not be considered for inclusion in this scoping review due to limitations in resources. Studies published from the year 2000 onwards will be included in this scoping review, as the notion of risk started to gain considerable attention in both academic and professional literature between 1999 and 2000[20], and the concept of risk started to emerge within social policy in some countries.[21] Studies published in English or French will be included for review.

Methods

Arksey and O'Malley proposed the original framework for conducting scoping reviews, which was then advanced and extended by Levac et al.[22,23] The proposed scoping review will be conducted in accordance with the updated JBI methodology for scoping reviews.[24,25] This protocol has been registered on Open Science Framework for transparency.

Search strategy

The search strategy will be designed to target only published studies. An initial search of Ovid MEDLINE (2000 to June 2020) was undertaken to identify articles on the topic. The text words covered in the titles and abstracts of relevant articles and subject terms used to describe the articles were used to develop a full search strategy for Ovid MEDLINE (2000 to June 2020; see Appendix I). In addition, a health sciences librarian was consulted to further develop the comprehensiveness of the search strategy. The search strategy, including all subject terms and free text terms will be adapted for each database search. The reference list of all included articles will be screened for additional studies.

The databases to be searched for the scoping review include Ovid AMED, Ovid EMBASE, Ovid PsycINFO, EBSCOhost CINAHL, EBSCOhost AgeLine. Sources of gray literature will be not included for this scoping review.

Study selection

After the search is completed, all identified citations will be collated and uploaded into Covidence (Veritas Health Innovation, Melbourne, Australia). Duplicates will be removed in Covidence prior to importing the citations into the JBI System for Unified Management, Assessment and Review of Information (JBI SUMARI; JBI, Adelaide, Australia).[27] From here, titles and abstracts will be screened by two independent reviewers for assessment against the inclusion criteria for the review. Studies that have been identified as potentially relevant will be retrieved in full and uploaded to JBI SUMARI. Then, the two independent reviewers will assess in detail the full text of the selected citations against the inclusion criteria. Full text studies that do not meet the inclusion criteria will be excluded and reasons for exclusion will be recorded and reported in the scoping review. Any disagreement between the reviewers at any stage of the selection process will be resolved through discussion, or with a third reviewer. The results of the search will be reported in full in the final review in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses for scoping reviews (PRISMA-ScR) flow diagram.[28]

Data extraction

A data extraction tool developed by the primary author will be used to extract the data from the included studies. The data extracted will include details about the study geographical location, study design and methods, and specific details regarding risk-taking behaviours. Specifically, risk-taking behaviours will be classified by the type of task (hypothetical choice, self-reported behaviour, and observed behaviour) using the methods by Byrnes and colleagues.[11] The socio-ecological model offers a broad perspective on health promotion and will be utilized for classification of potential determinants of fall-related, risk-taking behaviour.[18] A draft of the data extraction tool is included (see Appendix II) and will be modified and revised as necessary during the data extraction process. All amendments to the data extraction tool will be reported in the final scoping review. Authors from included studies will be contacted to request missing or additional data as needed. Any disagreements between the two independent reviewers regarding the data extraction will be resolved through discussion or with a third reviewer.

Data analysis and presentation

The extracted data will be presented in tables and diagrams in a manner that aligns with the objective of this scoping review. Risk-taking behaviours will be presented by listing who identified the risk and the method used to identify the behaviour (observed, self-reported, or hypothetical choice). The domains of the SEM will be used as a framework to help structure the presentation of the results. A narrative summary will accompany the tabled and/or charted results and will relate the results to the research questions.

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Conflicts of Interest

The authors declare no conflict of interest.

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Appendix I: Search strategy

OVID MEDLINE

Search conducted July 2020

Search	Query	Records retrieved
#1	exp Aged/ or / or (elder* or older adult* or senior*).mp.	3,230,053
#2	exp Accidental Falls/ or (fall* or slip* or trip*).mp.	646,894
#3	exp Choice Behaviour/ or exp Risk-Taking/ or exp Health Risk Behaviours or exp Self Concept/ or exp Perception/ or (risk adj3 behavio*).mp. or risk taking.mp. or (hazard* adj2 behavio*).mp. or (danger* adj2 behavio*).mp. or risk appraisal.mp. or risk evaluation.mp. or self-perception.mp. or self-perceived risk.mp. or self-perceived.mp. or (risk* adj3 estimate*).mp. or (risk* adj2 judgment*).mp. or (risk* adj3 perception*).mp. or (perceived adj3 risk*).mp. or perceived ability.mp. or (risk adj3 awareness).mp. or circumstance*.mp. or impulsiv*.mp. or sensation seeking.mp.	784,927
#4	#1 and #2 and #3	3400
#5	Limit #4 to (yr=”2000-Current”) and (english or French))	2691

Appendix II: Data extraction tool

Reviewer's initials: Date:

Article identifiers

Title:

First author's last name: Year:

Study location (country):

Article type

Experimental design:

- ☐ Randomized controlled trial
- ☐ Cross-over design
- ☐ Other:

Quasi-experimental design:

- ☐ Before and after
- ☐ Post-test
- ☐ Interrupted time-series
- ☐ Other:

Observational Designs:

- ☐ Case control
- ☐ Cross-sectional
- ☐ Case series
- ☐ Prospective cohort
- ☐ Case report
- ☐ Retrospective cohort
- ☐ Other

Qualitative Designs:

- ☐ Phenomenology
- ☐ Grounded theory
- ☐ Ethnography
- ☐ Action research
- ☐ Qualitative description
- ☐ Feminist research
- ☐ Interpretive description
- ☐ Narrative inquiry/analysis
- ☐ Other

Review designs:

- ☐ Systematic/meta-analysis
- ☐ Scoping review
- ☐ Narrative review
- ☐ Literature review
- ☐ Other

"Other" literature:

- ☐ Thesis
- ☐ Reports
- ☐ Other:

For experimental studies only

Sample size: Group mean age:

Int: %F %M Control: %F %M

For non-experimental studies only

Sample size: %F %M Group mean age:

Data collection:

- ☐ Face to face, individual
- ☐ Face to face, group
- ☐ Focus group
- ☐ Telephone
- ☐ Online
- ☐ Other:

Eligibility

- ☐ Community-dwelling older adults
- ☐ Group mean age ≥ 65 years
- ☐ Context of falls
- ☐ Risk-taking behaviour
- ☐ English or French language

Research Objective

Aim:

Article details

Study setting

- ☐ Community
- ☐ Other:
- ☐ Laboratory

Falls data collection ☐YES ☐NO

- ☐ Prospective
- ☐ Retrospective

Types of falls:

- ☐ Single falls
- ☐ Multiple falls
- ☐ Injurious falls
- ☐ Other:

Collection period:

- ☐ 18 months
- ☐ 12 months
- ☐ 6 months
- ☐ Other:

Collection frequency:

- ☐ Monthly
- ☐ Bi-weekly
- ☐ Weekly
- ☐ Other

Collection method:

- ☐ Diaries
- ☐ Other
- ☐ Fall calendars

Risk-taking behaviour as a predictor of future falls ☐Assessed ☐Not assessed

Results:

Research question 1&2: risk-taking behaviour

- ☐ Hypothetical choice
- ☐ Other:
- ☐ Self-reported
- ☐ Observed

Describe the ‘other’ risk-taking behaviour:

Hypothetical choice

- ☐ Choice dilemma
- ☐ Other
- ☐ Framing task

Describe the hypothetical choice:

Outcome measure:

Self-reported

- ☐ Failures of attention
- ☐ Failures of memory
- ☐ Other
- ☐ Errors of planning
- ☐ Deliberate decisions to act

Describe the self-reported behaviour:

Outcome measure:

Observed behaviour

- ☐ Choice task
- ☐ Other
- ☐ Physical ability estimation

Describe the task/ability observed in the study:

Outcome measure:

Research question 3: **predisposing factors of risk-taking behaviour (as per SEM)**

*predisposing factors

- ☐ Individual
- ☐ Interpersonal
- ☐ Organizational
- ☐ Community
- ☐ Public policy

Individual factors

- ☐ Knowledge
- ☐ Skills
- ☐ Attitudes
- ☐ Other:

Describe how the individual factor influenced risk-taking behaviour:

Interpersonal factors

- ☐ Families
- ☐ Social networks
- ☐ Friends
- ☐ Other:

Describe how the interpersonal factors influenced risk-taking behaviour:

Organizational factors

- ☐ Organizations
- ☐ Other:
- ☐ Social influences

Describe how organizational factors influenced risk-taking behaviour:

Community factors

- ☐ Cultural values
- ☐ Other:
- ☐ Community norms

Describe how community factors influenced risk-taking behaviour:
Public policy factors
☐ State ☐ Local laws and regulation ☐ Other:
Describe how public policy influenced risk-taking behaviour:

CHAPTER THREE

RISK-TAKING AND FALLS IN COMMUNITY-DWELLING OLDER ADULTS: A SCOPING REVIEW

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Risk-taking and falls in community-dwelling older adults: a scoping review

Abstract

Background: Risk-taking behaviours have emerged as a target for fall prevention. However, the concepts of risk-taking are complex and several approaches exist to identify risk-taking behaviours. Studies of fall-related risk-taking behaviours have not yet been systematically evaluated.

Objectives: The purpose of this review is to map the nature and extent of research conducted on risk-taking behaviours related to falls in community-dwelling older adults.

Research Design and Methods: This scoping review was conducted in accordance with Joanna Briggs Institute's methodology for scoping reviews. Six electronic databases were searched to identify studies published between 2000 and 2020. Studies were included in our review if they were conducted on community-dwelling older adults (≥ 65 years) and discussed fall-related risk-taking behaviours. Data extraction and thematic analyses were completed using a table developed a priori by the research team.

Results: Self-reported behaviours using qualitative methodology were the most common approach used to identify risk-taking behaviours in community-dwelling older adults. Generally, older adults are aware of their own fall risk and tend to adopt behaviours to help mitigate their fall risk. Older adults also described moments of deliberate risk-taking driven by the potential benefits of this behaviour. Factors associated with risk-taking include an individual's abilities, personal values, and the physical and social environment.

Discussion: This review demonstrated that fall-related risk-taking behaviours are a highly individualized concept influenced by a number of factors.

Implications: Future research should evaluate how risk appraisal, risk attitudes, and risk propensity predict fall-related risk-taking behaviours in community-dwelling older adults.

Keywords: behaviours, fall risk, risk appraisal, risk propensity, risk attitudes

Introduction

Falls affect one in three older adults annually and typically occur as a result of the interaction of biological factors with behavioural and environmental risks (Feldman & Chaudhury, 2008; World Health Organization (WHO), 2007). In 1999, the concept of behavioural risk, such as risk-taking in older adults, started to gain considerable attention in the gerontology literature (Adams, 2001; Clarke, 2006). Consequently, risk-taking behaviours emerged as a consideration for fall prevention education (Hill et al., 2009; Public Health Agency of Canada (PHAC), 2014; WHO, 2007). Given the subjectivity of risk-taking, concerns have been raised about stigma and ageism related to this topic, particularly when focus is placed on safety and risk avoidance (Clarke, 2006; Durocher et al., 2017; Rush et al., 2012).

Across all domains (i.e., ethical, financial, health/safety, recreational, and social), risk-taking has been examined from a scientific-medical, as well as a socio-cultural, perspective (Clarke, 2006; Rush et al., 2012; Sitkin & Pablo, 1992). The scientific-medical perspective conceptualizes risk as objective, external, measurable, and predictable (Adams, 2001). The individual bears the responsibility to make rational decisions about their behaviour which involves an explicit evaluation of potential benefits and harms (Rush et al., 2012). This perspective typically views risk-taking as unfavorable, often discouraging these behaviours to mitigate harm (Clarke, 2006; Haines et al., 2015; Rush et al., 2012). Conversely, the socio-cultural perspective views risk-taking as a constructive and important aspect of life that promotes autonomy and self-determination (Boyer, 2006; Bran & Vaidis, 2020; Clarke, 2006; Rush et al., 2012). Risk-taking behaviours are viewed as a product of an individual's subjective perception, judgment and meaning of risk and emphasizes the role of emotions and values in the decision-making process (Bran & Vaidis, 2020; Clarke, 2006; Rush et al., 2012).

Bran & Vaidis (2020) proposed a new typology for risk-taking that considers both the scientific-medical and socio-cultural perspectives of risk (Byrnes et al., 1999; Sitkin & Pablo, 1992). This typology outlines four core concepts to risk-taking: behaviours, propensity, attitudes, and appraisal (Bran & Vaidis, 2020). Risk-taking behaviours refer to the actions, or inactions, involving potential risks and are measured through reported behaviours (e.g., self-reports); projected behaviours (e.g., decisions in hypothetical scenarios); and actual behaviours (e.g., direct observation of behaviours). Risk-taking propensity is the degree to which individuals exhibit these behaviours. This propensity can be general (e.g., "I take chances") or specific to a particular domain (e.g., "I gamble"). Risk-taking attitudes, expressed in cognitive, affective, and behavioural responses, reflect the degree of preference to which an individual will favor or avoid risk. Cognitive responses refer to the information, knowledge, or beliefs one holds about risk-taking. Affective responses are the emotions and feelings evoked by taking risks, while behavioural responses are the willingness and motivation to take or avoid risks. Finally, risk appraisal (i.e., risk perception) describes the subjective assessment of the potential benefits and harms in a specific situation (Bran & Vaidis, 2020). Several models exist to explain risk appraisal (e.g., risk-as-feeling model) (Finucane & Holup, 2006)

Prominent reports discuss fall-related risk-taking behaviours from a scientific-medical perspective (e.g., PHAC, 2014; WHO, 2007), which encourage avoidance of specific activities (e.g., climbing ladders). However, these claims are supported with little evidence and fail to acknowledge the socio-cultural perspective of risk-taking. Risk-taking behaviours are relatively new in fall research, and currently no reviews on this topic exist. This scoping review will provide a comprehensive understanding of fall-related risk-taking behaviours in community-dwelling older adults. Scoping review methodology allows a systematic, yet iterative, approach to determine the extent and nature of a research topic (Arksey & O'Malley, 2005; Levac et al., 2010; Munn et al., 2018; Peters et al., 2020). Scoping reviews are employed to identify the types of available evidence, key characteristics, and concepts or to examine how research is conducted on a certain topic (Munn et al., 2018).

Aims and Research Questions

The objective of this study is to systematically review published studies discussing risk-taking behaviours related to falls in community-dwelling older adults. The questions guiding this review are:

1. What approaches have been used to identify fall-related risk-taking behaviours in community-dwelling older adults?
2. What fall-related risk-taking behaviours have been identified for community-dwelling older adults?
3. What factors influence fall-related risk-taking behaviours in community-dwelling older adults?

Methods

This study was conducted per Joanna Briggs Institute scoping review methodology (Peters et al., 2020) to identify key risk-taking concepts within the fall literature to provide a framework that can guide future research and clinical guideline development for fall prevention strategies for community-dwelling older adults. An a priori protocol for this review was published (Bégin et al, 2021) and registered on Open Science Framework (osf.io/r9f7v). The PRIMSA Extension for Scoping Reviews (PRIMSA-ScR; Tricco et al., 2018) guided the reporting of this scoping review (see Supplementary Materials).

Identifying Relevant Studies

As risk-taking behaviours gained considerable attention in geriatric literature in 1999-2000, a search strategy was developed in consultation with a health science research librarian to identify studies published from 2000 onward. A preliminary search of Ovid MEDLINE was undertaken using the terms 'risk-taking behaviour' and 'falls' to identify articles on the topic (Supplementary Materials).

The text word contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy adapted for each database (Bégin et al, 2021).

Six databases were searched on August 3, 2020, to identify articles for the review: Ovid AMED (2000 – August 2020), Ovid EMBASE (2000- August 2020), Ovid MEDLINE (2000 – August 2020), Ovid PsychInfo (2000- August 2020), EBSCOhost CINAHL (2000 – August 2020), EBSCROhost AgeLine (2000 – August 2020).

Study Selection

Study selection was conducted using Covidence (Veritas Health Innovation, Melbourne, Australia). Studies were included in our review if they were conducted with community-dwelling older adults and discussed fall-related risk-taking behaviours. Community-dwelling older adults were defined as those over the age of 65 years who lived within the community. The cut-off of 65 years was selected as many institutions consider older adults as 65 years or older (e.g., PHAC, 2014). Studies with populations of community-dwelling older adults <65 years were excluded from this review. Three reviewers (DB, AM, SW) independently reviewed the first 20 titles and abstracts and compared findings to ensure agreement and consistency in applying the inclusion criteria (Table 1). Then, two reviewers (DB, AM) independently screened the remaining titles and abstracts for relevancy against the inclusion criteria. Seven article full texts were selected for assessment by three reviewers (DB, AM, SW) to ensure clarity and consistency with the inclusion criteria. Two reviewers independently assessed the remaining English (DB, AM) and French (DB, JL) full texts for eligibility. Full-text studies that did not meet the inclusion criteria were excluded, and reasons for exclusion noted. Disagreements between reviewers at abstract or full-text screening were resolved first through discussion between two reviewers or when needed with a third reviewer (SW).

Data Extraction and Analysis

Three reviewers (DB, AM, SW) independently completed data extraction for five full-text articles using the extraction tool developed a priori. The form extracted information on study characteristics, research aims, assessment description, and rationale, and factors associated with risk-taking behaviours (Supplementary Materials) (Bégin et al., 2021). Upon completion of this exercise slight modifications were made to the data extraction form: delineation of the four core concepts of risk-taking and who identified the behaviour.

One reviewer (DB) completed data extraction for all included full texts. If uncertainties arose during data extraction, a second reviewer assisted (SW or JL). The framework used to guide data extraction was modified from the previously published protocol (Bégin et al., 2021) as an updated framework became available after protocol publication but prior to starting data extraction (Bran & Vaidis, 2020). Information extracted from the articles was organized to explore the approaches and methods used to identify fall-related risk-taking behaviours and categorized according to Bran & Vaidis (2020) four core concepts of risk-taking: risk-taking behaviours (i.e., actions or inaction involving potential risk), risk appraisal (i.e., the subjective assessment of risk), risk-taking propensity (i.e., tendency to engage in risk situations), and risk-taking attitudes (i.e., tendencies to evaluate risk with some degree of favor or disfavor).

Results

The search identified 7649 citations for a total of 5060 titles after removal of duplicates. Following title and abstract screening, 216 articles were identified as potentially relevant and uploaded to Covidence for full-text review. Of the full text uploaded, 187 were excluded, as the majority of these studies (n = 83) discussed circumstances of falls not related to risk-taking behaviours (e.g., locations and type of falls) (Figure 1). A total of 30 articles were included for data extraction and synthesis (Azzarello & Hall, 2016; Bailey et al., 2011; Berlin Hallrup et al., 2009; Blalock et al., 2016; Bleijlevens et al., 2010; Brundle et al., 2015; Butler et al., 2011, 2015; Cayado & Chahbi, 2015; Chaumon et al., 2016; Clemson, Cumming, et al., 2003; Clemson, Manor, et al., 2003; Crenshaw et al., 2017; Dollard et al., 2012; Horton, 2007; Kilian et al., 2008; Kim & Ahrentzen, 2017; Kluft et al., 2017; Lehtola et al., 2006; Mackenzie et al., 2002; Nachreiner et al., 2007; Nyman et al., 2013; Pohl et al., 2015; Robson et al., 2018; Roe et al., 2008; Sattar et al., 2019; Stevens et al., 2014; Tomczak et al., 2021; Weijer et al., 2019; Zecevic et al., 2009).

Characteristics of Included studies

All 30 studies selected in this scoping review were conducted in high-income countries (See Figure 2). The majority of articles were from Australia (23.3%, n = 7; Butler et al., 2011, 2015; Clemson, Cumming, et al., 2003; Clemson, Manor, et al., 2003; Dollard et al., 2012; Mackenzie et al., 2002; Robson et al., 2018) and the United States of America (23.3%, n = 7; Azzarello & Hall, 2016; Blalock et al., 2016; Crenshaw et al., 2017; Kim & Ahrentzen, 2017; Nachreiner et al., 2007; Stevens et al., 2014; Tomczak et al., 2021). Additionally, the majority of studies utilized qualitative methodology (53.3%, n = 16) and a sample with ≥ 50% female participants (90%, n = 27). A summary of each study's publication year, geographical location, population, and falls data collection is presented in Table 2.

Risk-Taking Behaviours

This review aimed to identify approaches used in the literature to assess or explore older adults' risk-taking behaviours concerning falls. Using the Bran & Vaidis (2020) framework, two approaches to categorizing fall-related risk-taking behaviours in community-dwelling older adults were used: reported (Bailey et al., 2011; Berlin Hallrup et al., 2009; Bleijlevens et al., 2010; Brundle et al., 2015; Cayado & Chahbi, 2015; Chaumon et al., 2016; Clemson, Manor, et al., 2003; Crenshaw et al., 2017; Horton, 2007; Kilian et al., 2008; Kim & Ahrentzen, 2017; Lehtola et al., 2006; Mackenzie et al., 2002; Nachreiner et al., 2007; Nyman et al., 2013; Pohl et al., 2015; Robson et al., 2018; Roe et al., 2008; Sattar et al., 2019; Stevens et al., 2014; Tomczak et al., 2021; Zecevic et al., 2009) and actual (Bailey et al., 2011; Butler et al., 2011, 2015; Cayado & Chahbi, 2015; Kluft et al., 2017; Weijer et al., 2019) (Figure 3). None of the included studies used projected behaviours (i.e., intentions or decisions in a hypothetical situation) to measure fall-related risk-taking behaviours in community-dwelling older adults. As the methods used to identify fall-related risk-taking behaviours influenced how behaviours were perceived, risk-taking behaviours are also reported below.

Reported risk-taking behaviours. Individuals' self-reports of past or current behaviours were the most common approach (n = 22) used to identify fall-related risk-taking behaviours. These studies explored risk-taking behaviours through self-reflection of fall events (n = 15) (Bleijlevens et al., 2010; Brundle et al., 2015; Chaumon et al., 2016; Clemson, Manor, et al., 2003; Crenshaw et al., 2017; Kim & Ahrentzen, 2017; Lehtola et al., 2006; Mackenzie et al., 2002; Nachreiner et al., 2007; Nyman et al., 2013; Roe et al., 2008; Sattar et al., 2019; Stevens et al., 2014; Tomczak et al., 2021; Zecevic et al., 2009) and open-ended discussion regarding personal behaviours and routines (n = 7) (Bailey et al., 2011; Berlin Hallrup et al., 2009; Cayado & Chahbi, 2015; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Robson et al., 2018).

Eight studies gathered information on fall events using qualitative methods to capture older adults' perceived causes of an experienced fall (Brundle et al., 2015; Chaumon et al., 2016; Clemson, Manor, et al., 2003; Kim & Ahrentzen, 2017; Nyman et al., 2013; Roe et al., 2008; Sattar et al., 2019; Zecevic et al., 2009). The findings from qualitative studies identified various factors leading to a fall, which included risk-taking behaviours. In these studies, older adults' perceived causes of falls were typically attributed to cognitive factors including misjudgments, rushing unnecessarily, inattention, or carelessness. Some participants also discussed engaging in risk-taking behaviours as the cause of their fall, which usually involved climbing objects such as step ladders or chairs. One study analyzed fall incidents using the Seniors Falls Investigation Methodology (SFIM), which explored safety deficiencies that contributed to falls using a systems approach (Zecevic et al., 2009). This systems approach explores the sequence of events that contributed to the fall and places unsafe acts or decisions within the physical and social environment (Zecevic et al., 2009).

Quantitative studies (n = 8) that explored risk-taking behaviours focused on reporting the distribution of falls that occurred during specific activities (e.g., riding a bicycle, gardening) or movements (e.g., walking, climbing stairs, turning) (Bleijlevens et al., 2010; Crenshaw et al., 2017; Lehtola et al., 2006; Mackenzie et al., 2002; Nachreiner et al., 2007; Sattar et al., 2019; Stevens et al., 2014; Tomczak et al., 2021). Nachreiner et al., (2007) identified cognitive factors such as inattentiveness and rushing/hurrying as common contributors to falls. The authors also considered behaviours such as carrying objects in both hands, reaching for objects, and climbing a ladder or step stool as risk-taking behaviours for falls (Nachreiner et al., 2007). Lehtola et al., (2006) identified 'undertaking a risky task' as the cause of nine falls in their study; however, it is unclear which tasks were viewed as risky.

Seven studies collected information on risk-taking behaviours using face-to-face interviews or focus groups (Bailey et al., 2011; Berlin Hallrup et al., 2009; Cayado & Chahbi, 2015; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Robson et al., 2018). Older adults described themselves as responsible and capable of making rational decisions based on their physical abilities and the potential risks of their behaviours. In some studies, participants described modifying their behaviours in response to age-related changes to mitigate their falls risk while engaging in activities of daily living (Berlin Hallrup et al., 2009; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Roe et al., 2008). This included increased caution and awareness, pre-planning activities, using 'common sense', seeking support when necessary, and modifying their physical environment (Berlin Hallrup et al., 2009; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Roe et al., 2008). Older adults also described deliberate acts of risk-taking such as climbing onto a step ladder or chair to accomplish a task such as cleaning or reaching for objects (Berlin Hallrup et al., 2009; Brundle et al., 2015; Cayado & Chahbi, 2015; Pohl et al., 2015; Robson et al., 2008). In these situations, older adults viewed the importance of maintaining a clean environment, completing maintenance work, such as changing a lightbulb or being able to access items high off the ground, as outweighing the potential negative consequences of falling from an elevated surface (Berlin Hallrup et al., 2009; Brundle et al., 2015; Cayado & Chahbi, 2015; Pohl et al., 2015; Robson et al., 2008).

Actual Risk-Taking Behaviours. Direct observation of behaviours by a research team was the second most frequent approach (n = 6) used to identify fall-related risk-taking behaviours (Bailey et al., 2011; Butler et al., 2011, 2015; Cayado & Chahbi, 2015; Kluft et al., 2017; Weijer et al., 2019). Two studies utilized field observations in participants' homes to observe behaviours and daily routines that might increase falls risk (Bailey et al., 2011; Cayado & Chahbi, 2015). The findings from these studies displayed a discrepancy between researchers' and older adults' subjective assessment of risk-taking behaviours (research question 2). The research from these two studies identified several behaviours as risk-taking that the older adults did not recognize or consider risk-taking behaviours (e.g., using a step ladder to reach for an object).

Four studies evaluated discrepancies between self-perceived and actual ability in a research laboratory (Butler et al., 2011, 2015; Kluft et al., 2017; Weijer et al., 2019). Three studies evaluated the degree of misjudgment between perceived and actual step width (Kluft et al., 2017; Weijer et al., 2019), step over ability (Weijer et al., 2019), and reach distance (Butler et al., 2011) as proxy measures for fall-related risk-taking behaviours. The authors of these studies hypothesized an overestimation of one's ability could lead to excessive risk-taking. These studies asked participants to judge their maximal ability (e.g., step over height), followed by performing the task (stepping over a hurdle) until they reached their maximal ability. The degree of misjudgment was calculated as the difference between perceived and actual ability. Butler et al., (2011) found 15.2% of their study population overestimated reach distance, but misjudgment of reach ability was not associated with retrospective ($p = 0.76$) or prospective fall rates ($p = 0.59$). Butler et al., (2015) approached evaluation of risk-taking behaviours by using a choice task that involved participants making a judgment on their ability. In this study, participants chose between six walking paths to reach a visible destination as quickly as possible. Each path required the participant to cross a plank, with the shortest path having the most challenging plank (Butler et al., 2015). A significant, but moderate association was found between the everyday risk-taking scale and more difficult path choices ($r = 0.45$, $p < 0.001$) (Butler et al., 2015). However, individuals who took greater objective behavioural risks (i.e., had a higher probability of falling off the chosen path) reported lower risk-taking behaviours on the everyday risk-taking scale ($p < 0.05$) (Butler et al., 2015).

Factors Associated with Risk-Taking Behaviours

We also categorized articles according to the three concepts of risk-taking; risk appraisal (i.e., subjective assessment of risk), risk-taking propensity (i.e., consistent tendency to engage in risk situations), and risk-taking attitudes (i.e., tendencies to evaluate risk with some degree of favor or disfavor) as these concepts are strongly linked to risk-taking behaviours (Boyer, 2006; Bran & Vaidis, 2020; Fox & Tannenbaum, 2011).

Risk Appraisal. Eleven articles explored or evaluated older adults' subjective assessment of risk associated with fall situations (Azzarello & Hall, 2016; Bailey et al., 2011; Blalock et al., 2016; Brundle et al., 2015; Cayado & Chahbi, 2015; Dollard et al., 2012; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Robson et al., 2018; Roe et al., 2008). Individuals typically appraise risks according to the severity of the potential consequences that may occur, the likelihood that these negative consequences will occur (i.e., vulnerability), and the potential rewards of the risk (Bran & Vaidis, 2020). These studies discussed a variety of factors that influenced an older adults' appraisal of risk, in which we identified four main sub-themes: the value of upholding personal identity, prior experiences, environmental influences, and other.

Nine studies (Azzarello & Hall, 2016; Bailey et al., 2011; Cayado & Chahbi, 2015; Dollard et al., 2012; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Robson et al., 2018; Roe et al., 2008) discussed the influence of *upholding identity* on older adults' appraisals of risks. In these studies, most participants viewed the loss of independence and autonomy as a greater consequence than the potential consequences of a fall. This resulted in the adoption of behaviours ranging from protective behaviours (e.g., modifying pace) to risk-taking (e.g., climbing a step ladder to reach for an object).

Five studies (Brundle et al., 2015; Cayado & Chahbi, 2015; Pohl et al., 2015; Robson et al., 2018; Roe et al., 2008) demonstrated the role of *prior experiences* on older adults' risk appraisal. Previous experience of a fall often influenced an older adults' perception of both risk severity and vulnerability, and frequently resulting in the uptake of protective behaviours (Brundle et al., 2015; Pohl et al., 2015; Robson et al., 2018; Roe et al., 2008). In three studies (Cayado & Chahbi, 2015; Pohl et al., 2015; Robson et al., 2018), participants also discussed how prior success in an activity promoted engaging in behaviours that another individual may view as risk-taking (Cayado & Chahbi, 2015; Robson et al., 2018).

Three studies (Brundle et al., 2015; Horton, 2007; Robson et al., 2018) also discussed how the *environment* influenced an individual's risk appraisal. For example, participants discussed walking within familiar environments as low risk, whereas walking outside of typical environments was associated with a greater risk of falling (Brundle et al., 2015; Horton, 2007).

Two studies (Azzarello & Hall, 2016; Blalock et al., 2016) were grouped under the sub-theme of '*other*' due to their approach to understanding older adults' perceptions of fall risk factors. Azzarello & Hall (2016) explored older adults' situational awareness (i.e., how an individual perceives and interprets the meaning of risk in the environment) during a video simulation of an older woman performing daily activities. Throughout the scenario, most participants (81.8%) identified one or more risks; yet none were interpreted in the context of falls (Azzarello & Hall, 2016). For example, the older woman walking in socks was viewed as a risk for a foot injury (Azzarello & Hall, 2016, p. 164). This demonstrates most older adults may recognize risks are present in their daily routine yet may not interpret risks in the context of falls. Blalock et al., (2016) explored the relationship between perceived risk of falling, measured by a single item question, and the adoption of precautions to reduce fall risk. This study found men had a lower perceived risk of falling compared to women ($p < 0.10$), as well as an association between awareness of risk-prevention behaviours and higher perceived risk of falling (Blalock et al., 2016).

Risk-Taking Attitudes. Two articles explored older adults' degree of preference to engaging in behaviours that increased the likelihood of falls (Bran & Vaidis, 2020). Participants from both studies (Kilian et al., 2008; Pohl et al., 2015) described strong affective responses evoked when deliberately ignoring their falls risk. Deliberate acts of risk-taking were often expressed as defiant behaviour to uphold their image and combat patronizing comments from others – particularly comments from their children (Kilian et al., 2008; Pohl et al., 2015).

Risk-Taking Propensity. Four articles assessed consistent tendencies of engaging in behaviours that exposed an older adult to falls and were grouped under risk-taking propensity (Bran & Vaidis, 2020). Two studies objectively measured older adult's fall-related risk-taking propensity using a scale. (Butler et al., 2015; Clemson, Cumming, et al., 2003). Both scales measure the frequency of risk-taking behaviours listed, with response options of never, sometimes, often, always, and does not apply as an additional option for the Falls Behavioural Scale for Older People (FaB) scale. The FaB is a 30-item scale developed for healthcare professionals as a tool to prompt discussion on risk-taking behaviours and to guide education on behavioural change. The FaB has demonstrated good internal consistency (Cronbach's α = 0.84), and test-retest reliability ($ICC_{2,1}$ = 0.94, 95% CI not provided). The Everyday Risk-Taking Scale is a 10-item scale with good internal consistency (Cronbach's α = 0.7) and test-retest reliability ($ICC_{3,1}$ = 0.85, 95% CI 0.71-0.92) in community-dwelling older adults (Butler et al., 2015). Both studies found significant differences in risk-taking propensity between males and females, with males reporting greater engagement in everyday behaviours and actions that could increase fall risk (Butler et al., 2015; Clemson, Cumming, et al., 2003).

Two studies (Berlin Hallrup et al., 2009; Kilian et al., 2008) indirectly addressed risk-taking propensity through open-ended discussions on everyday routine behaviours. In these studies, older adults described their natural tendencies to engage or not engage in fall-related risk-taking behaviours. Prior fall experience and the value of maintaining independence were dominant factors that influenced participants' risk-taking propensity (Berlin Hallrup et al., 2009; Kilian et al., 2008).

Discussion

The objective of this scoping review was to provide a comprehensive overview of fall-related risk-taking behaviours in community-dwelling older adults. This was accomplished by investigating the methods used to identify or measure fall-related risk-taking behaviours, exploring behaviours marked as risk-taking for falls, and the factors associated with these behaviours. Findings from this review demonstrate that generally, older adults are aware of their own falls risk and tend to adopt behaviours to help mitigate their falls risk (Bailey et al., 2011; Berlin Hallrup et al., 2009; Cayado & Chahbi, 2015; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Robson et al., 2018). Nevertheless, older adults also described deliberate acts of risk-taking, which are driven by the potential rewards of the behaviour (Kilian et al., 2008; Pohl et al., 2015).

Self-reported behaviours gathered through qualitative methodologies was the most common approach used to identify fall-related risk-taking behaviours in community-dwelling older adults. Specifically, this review identified two sub-approaches to collecting data on self-reported risk-taking behaviours: i) open-ended discussions on everyday behaviours or ii) self-reflection of fall events. The first approach involved gathering information on older adults' everyday behaviours through open-ended discussions (Bailey et al., 2011; Berlin Hallrup et al., 2009; Cayado & Chahbi, 2015; Horton, 2007; Kilian et al., 2008; Pohl et al., 2015; Robson et al., 2018). Although these studies did not directly aim to explore fall-related risk-taking behaviours, participants in these studies openly discussed their perceptions of fall risk and everyday behaviours, including risk-taking. The second approach involved gathering information on older adults' perceived causes of falls (Brundle et al., 2015; Chaumon et al., 2016; Clemson, Manor, et al., 2003; Kim & Ahrentzen, 2017; Mackenzie et al., 2002; Nyman et al., 2013; Roe et al., 2008; Sattar et al., 2019; Zecevic et al., 2009). Not surprisingly, participants in these studies described a wide range of factors that could have contributed to their falls. The use of self-reported behaviours identified by this review is consistent with the literature which explores risk-taking across all domains (i.e., ethical, economic, social, health/safety, and recreational) (Blais & Weber, 2006; Boyer, 2006; Bran & Vaidis, 2020; Byrnes et al., 1999). However, qualitative methodologies are not the primary method used in other domains of risk-taking literature as standardized scales have been developed (e.g., the Domain-Specific Risk-Taking Scale; Blais & Weber, 2006), and research focus has shifted towards quantifying and predicting risk-taking behaviours (Farnham et al., 2018; Gullone & Moore, 2000; Lejuez et al., 2003). In general, qualitative methodologies are used to explore risk-taking behaviours in new contexts or further explore the contextual factors of known risk-taking behaviours (e.g., Jones et al., 2017).

Discrepancies in perceptions of risk-taking behaviours between older adults and researchers were also identified in this review. These discrepancies are important to consider when assessing risk-taking behaviours, as an individual's subjective perception of risk may not align with the perceptions of the larger community (Byrnes et al., 1999). Societal views on aging directly impact older adults' behaviours and self-perceptions (Coudin & Alexopoulos, 2010; Hanson et al., 2009; Kornadt et al., 2020). Older adults are often depicted as a homogenous group, despite evidence the aging process is individualized and only loosely associated with chronological age (WHO, 2008). Negative stereotypes and stigma are often perpetuated through generalizations about aging, especially in regard to falls (Durocher et al., 2017; Egan et al., 2017; Hanson et al., 2009).

Labeling an older adult as a "faller" poses a serious threat to their self-identity (Bailey et al., 2011; Berlin Hallrup et al., 2009; Cayado & Chahbi, 2015; Dollard et al., 2012; Horton, 2007; Kilian et al., 2008; Robson et al., 2018; Ragingal., 2008). This concept of identity is a crucial explanatory variable in understanding fall-related risk-taking behaviours in community-dwelling older adults (Han et al., 2019; Miller, 2008; Zinn, 2019). Older adults strive to be viewed by society as physically competent and independent, which in turn influences a variety of risk-taking behaviours, including wearing high heels and climbing step ladders (Bailey et al., 2011; Berlin Hallrup et al., 2009; Cayado & Chahbi, 2015; Dollard et al., 2012; Hanson et al., 2009; Horton, 2007; Kilian et al., 2008; Robson et al., 2018; Roe et al., 2008). In these situations, the benefits of being viewed positively by society appear to outweigh the potential risk of a fall.

Another important consideration when assessing risk-taking behaviours relates to an individual's skill level – or in the case of falls, an individual's physical abilities (Byrnes et al., 1999). Reports on falls in older adults classify behaviours such as climbing objects (e.g., ladders) as risk-taking behaviours (PAHC, 2014; WHO, 2007). However, an older adult's physical abilities and familiarity with an activity will influence the level of risk associated with day-to-day activities. This review demonstrates that older adults who regularly climb chairs without any adverse events do not consider this risk-taking. It remains unclear whether these behaviours are truly risk-taking or discredited as such. Although functional decline is part of the natural aging process, it is neither linear nor consistent, and thus functional abilities in older adults are highly varied (WHO, 2018). To illustrate this variability, a systematic review by Mckendry et al., (2018) demonstrated master endurance athletes (defined as athletes ≥ 60 years) exhibited comparable aerobic capacity (i.e., VO2max) and master strength/power athletes exhibited comparable maximal voluntary contraction as young, healthy controls. Several studies have demonstrated a relationship between higher levels of physical activity and lower rates of disability in community-dwelling older adults (Bauman et al., 2016; Dunlop et al., 2005; Merom et al., 2012; Unger et al., 1997). In addition, the literature clearly identifies exercise interventions are effective at increasing older adults' physical abilities (Campbell & Robertson, 2003; Edwards & Pilutti, 2017; Lam et al., 2018; Neri et al., 2017; Papa et al., 2017; Varahra et al., 2018). Older adults' physical abilities should be viewed in the same way as skilled actions; through practice and repetition (i.e., regular physical activity), older adults can improve their physical abilities and reduce the risk of falling during many day-to-day activities.

A third consideration when assessing risk-taking behaviours, as highlighted by Byrnes et al., (1999) relates to the contextualization of behaviours. The way an action is performed may increase or decrease the level of risk associated (Byrnes et al., 1999). This review identified how factors such as rushing, inattention, and carelessness can increase the level of risk associated with a relatively basic action (e.g., walking). The SFIM demonstrates the complexity and diversity of fall incidents (Zecevic et al., 2009). The SFIM placed unsafe acts and risk-taking behaviours within a broader context, revealing systemic factors contributing to risk-taking behaviours. For example, shutting off lights was considered unsafe, yet participants viewed it as necessary to reduce their electricity bill (Zecevic et al., 2009). Similarly, Chaumon et al., (2016) demonstrated how social circumstances were factors that conditioned risk-taking. This finding is consistent with the literature exploring risk-taking behaviours from a socio-cultural perspective (Boyer, 2006; Zinn, 2019).

Implications for future research

Considering the concerns described above (i.e., subjective perception of risk, self-perception, physical abilities, and the context of the behaviours), and in conjunction with the complex nature of falls, developing standardized measures of fall-related risk-taking behaviours can be challenging. The FaB scale (Clemson, Cumming, et al., 2003) has many items directly related to physical function. Older adults who can perform activities without the additional assistance described in the scale (e.g., using a handrail to climb stairs) might inappropriately be flagged as risk-takers. Additional research is required to understand the relationship between physical function and FaB scale scores to determine which populations are most appropriate for this scale (e.g., frail older adults vs. active adults). Research should also assess determinant frameworks from well-established risk-taking domains (e.g., Stikin & Pablo, 1992) to adapt to the context of fall-related risk-taking behaviours in community-dwelling older adults. This includes evaluating mediating and moderating factors that influence the relationship between risk appraisal, risk attitudes and risk propensity that leads to fall-related risk-taking behaviours.

Limitations

There are limitations to the findings of this study. First, we did not consider grey literature, limiting our findings to articles published in academic journals. Secondly, we did not consider studies that included participants < 65 years of age, which resulted in the exclusion of 46 articles. It is unknown if these excluded articles had similar approaches to identifying risk-taking behaviours as the studies included in this review, and future research should explore if risk-taking behaviours differ in younger populations who may be at risk of falling. Last, the exclusion of studies published prior to 2000s may have resulted in the omission of earlier concepts related to risk taking, impacting the internal validity of the results.

Conclusion

This scoping review explored fall-related risk-taking behaviours using Bran & Vaidis (2020) four core concepts of risk-taking. As falls are a complex multifactorial phenomenon, fall-related risk-taking behaviours can be challenging to identify. This review demonstrated a variety of factors influence risk-taking behaviours, including an individual's physical abilities, the surrounding environment (social and physical), and how the activity was performed (e.g., rushing vs. going slowly). This review also identified the FaB scale and the

Everyday Risk-Taking scale as outcome measures which could be used to measure risk-taking propensity. However, it is important to recognize that responses in these scales may vary according to an individual's physical ability and not their risk-taking propensity. Risk is a highly individualized concept, and therefore researchers assessing risk-taking behaviours must consider the interaction of complex factors and how to objectively assess these relationships.

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Table 1. Inclusion and Exclusion Criteria

	Include	Exclude
Study Year	Year 2000 and onwards	Fear of Falling/Fall Efficacy/Balance Confidence Studies that describe circumstances of falls but do not describe the behaviour (e.g., slipping on water is not risk-taking, unless associated with a deliberate action –choosing to walk through the water) Studies that describe situations where a service provider was neglectful that results in a fall
Study Design	Original Study	
Population	Community-Dwelling Older Adults (≥65 years)	
Setting	Community	
	Laboratory	
	Hospital If fall occurred in the community/ population is community-dwelling older adults	
Context	Falls	
Concept	**Risk-taking behaviour:** *engagement in any observable movement associated with a degree of uncertainty about the outcomes of the behaviour* <u>Includes:</u> Behaviours that involve moderate to high-short term gain, followed by the potential for greater long-term loss (Leather, 2009) - Deliberate acts against recommendations from HCP (e.g., participant was advised to remove rug in the living room but has not removed it) - Recognizing their own risk and not seeking aid (e.g., purchasing a used assistive device/ not getting it fitted/education on proper use) - Participants are asked to choose between two imaginary options or choose a level of risk that they would tolerate in a hypothetical situation. - Participants report how often they engaged in various risky behaviours/ describe situations where they took a risk that led to a fall. - Participant’s behaviours are observed by the researcher - Participant’s behaviours are evaluated in a laboratory setting <u>Outcome Measures:</u> A) Researcher must identify the measure (or component) as measuring risk-taking behaviours OR B) The measure evaluates the **likelihood/tendency** of the person engaging in behaviours that have been identified as risky (e.g., climbing ladders)	

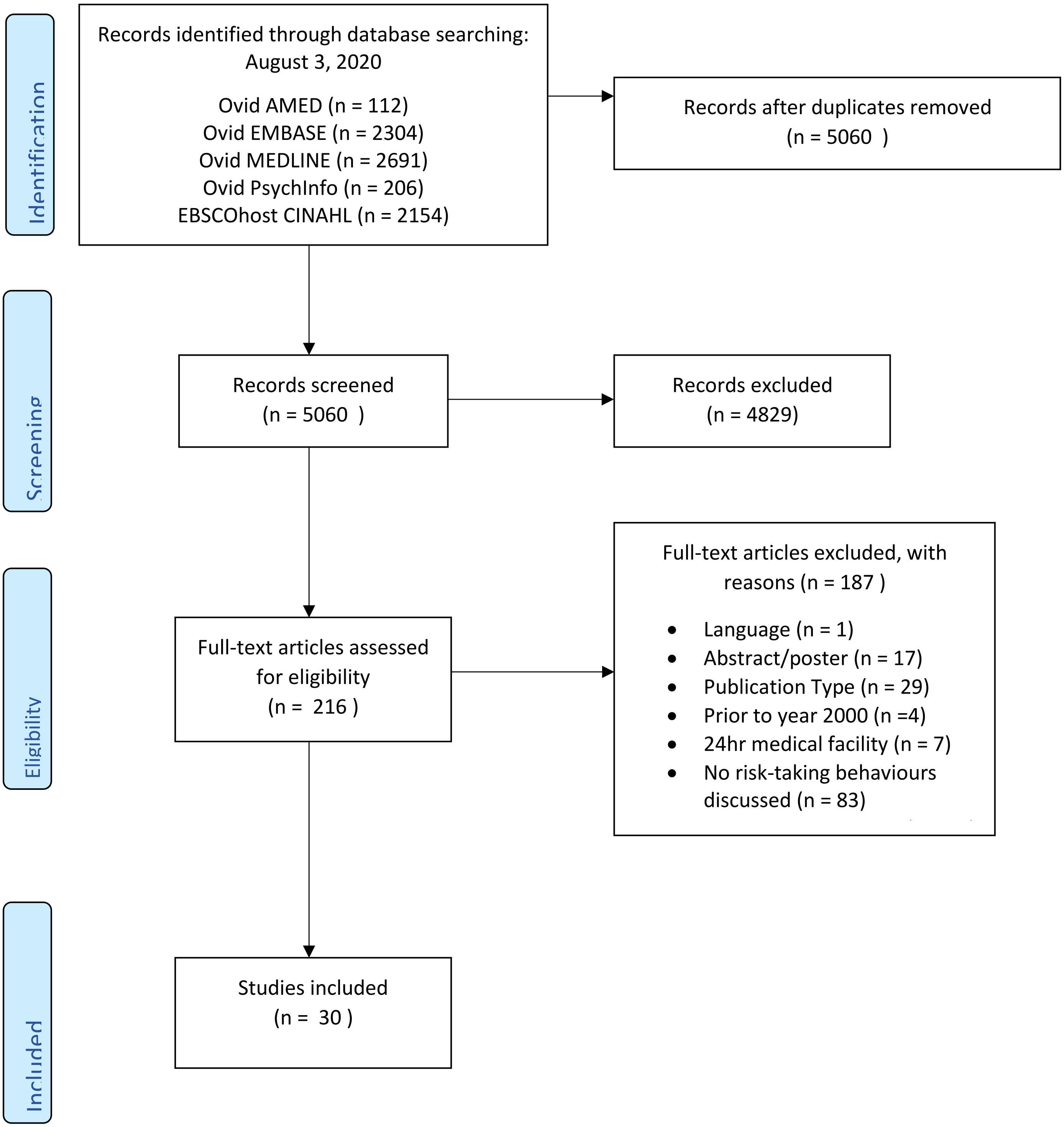
Table 2. Characteristic of Included Studies

Author (Year)	Country	Population			Falls Collection	Risk-Taking			
		Sample Size	% Female	Age		Behaviour	Propensity	Attitudes	Appraisal
Qualitative Studies (n = 15)									
Azzarello & Hall (2016)	US	11	64.0%	Minimum 65 years Maximum 89 years	N/A				X
Bailey et al (2013)	IE	8	62.5%	Minimum 70 years Maximum 87 years	N/A	X			X
Berlin Hallrup et al (2009)	SE	13	100.0%	Minimum 76 years Maximum 86 years	N/A	X	X		
Brundle et al (2015)	UK	54	70.3%	Mean Age 83 years	N/A	X			
Cayado & Chahbi (2015)	FR	50	Mostly female	Mean Age: 77 years	N/A	X			X
Chaumon et al (2016)	FR	63	88.0%	Mean Age 84 years	N/A	X			
Clemson, Manor, et al (2003)	AU	15	100.0%	Mean Age 78 years	Retrospective	X			
Dollard et al (2012)	AU	9	66.6%	Minimum 65 years Maximum 86 years	N/A				X
Horton (2007)	UK	40	50.0%	Minimum 65 years Maximum 94 years	Retrospective	X			X
Kilian et al (2008)	CA	8 older adults 6 adult children	87.5%	Older Adult Mean Age: 81.4 years Adult Children Mean Age: 56.5 years	N/A	X	X	X	X
Nyman et al (2013)	UK	44	84.0%	Mean Age: 78 years	N/A	X			
Pohl et al (2015)	SE	18	55.0%	Mean Age 74.6 years SD = 3.5 years	Retrospective	X		X	X
Robson et al (2018)	AU	26	Interview: 84.6% Focus Group: 76.9%	Minimum 65 years Maximum 84 years	N/A	X			X
Roe et al (2008)	UK	27	81.5%	Mean Age 87 years	N/A	X			X
Zecevic et al (2009)	CA	15	73.0%	Mean Age 79 years SD = 7 years	Prospective	X			
Quantitative Studies (n = 13)									
Blalock et al (2016)	US	124	75.6%	Mean Age 79.6 years SD = 8.1 years	Retrospective				X
Bleijlevens et al (2010)	NL	333	69.0%	74.9 years SD = 6.4 years	N/A	X			
Butler et al (2011)	AU	415	55.4%	Mean Age 77.3 years SD = 4.5 years	Prospective and Retrospective	X			
Butler et al (2015)	AU	300	52.3%	Mean Age 77.4 years SD = 4.6 years	Prospective	X	X		
Clemson, Cumming et al (2003a)	AU	418	77.0%	Mean Age 76.8 years	N/A		X		
Crenshaw et al (2017)	US	125	100.0%	Mean Age 77.1 years SD = 7.5 years	Prospective and Retrospective	X			
Kluft et al (2017)	NL	27	59.3%	Mean Age 77.4 years	Retrospective	X			

				SD = 5.6 years					
Lehtola et al (2006)	FI	555	77.0%	Median Age: 88 years	Prospective	X			
Mackenzie et al (2002)	AU	309	44.7%	70-80 years: 73.5% ≥ 80 years: 26.5%	Prospective	X			
Nachreiner et al (2007)	US	263	100.0%	Minimum 70 years Maximum 99 years	Prospective	X			
Stevens et al (2014)	US	328	72.3%	65-74: 30.2% 75-84: 48.2% 85+: 21.6%	Prospective	X			
Tomczak et al (2020)	US	51	37.0%	Mean Age 72.2 years SD = 4.8 years	Prospective	X			
Weijer et al (2019)	NL	269	68.8%	Median Age 69.9, IQR = 7.1 years	N/A	X			X
Mixed-Methods Studies (n = 2)									
Kim & Ahrentzen (2017)	US	14	100.0%	Mean Age 88 years	Retrospective	X			
Sattar et al (2019)	CA	100	38.0%	Median Age 76 years	Prospective	X			

AU = Australia, CA = Canada, FI = Finland, FR = France, IE = Ireland, NL = Netherlands, SE = Sweden, UK = United Kingdom, US = United States of America
SD = standard deviation , N/A = Not assessed

Figure 1. PRISMA 2009 Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Figure 2. Distribution of Studies per Country

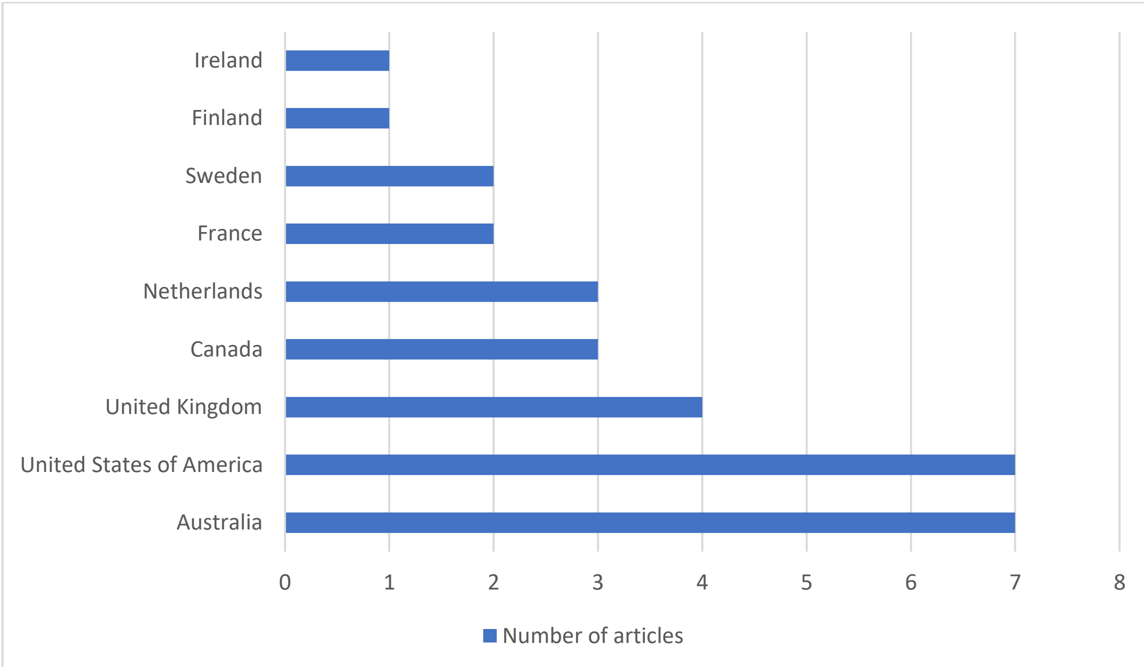
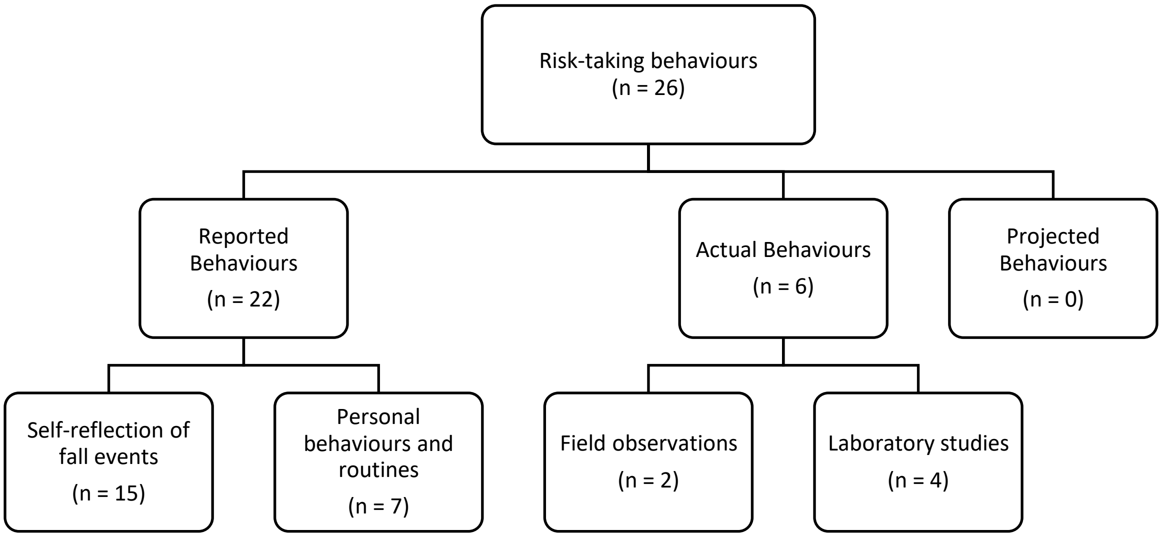


Figure 3. Assessments of Risk-Taking Behaviours



*****Note two studies (Bailey et al., 2011; Cayado & Chahbi, 2015) included evaluations for reported and actual behaviour

Supplementary Materials

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	2-3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	3
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	4
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	4, Supp Mat
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	4
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	2, 4
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe	N/A

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
		the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	4
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	5
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	5
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	5
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	5-10
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	10-12
Limitations	20	Discuss the limitations of the scoping review process.	13
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	13
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	N/A

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

Search Strategy

OVID MEDLINE (02/07/2020)		
#	**Searches**	**Results**
1	exp Aged/ or / or elder*.mp. or older adult*.mp. or senior*.mp.	3,230,053
2	exp Accidental Falls/ OR fall*.mp. OR slip*.mp. OR trip*.mp.	646,894
3	exp Choice Behaviour/ or exp Risk-Taking/ or exp Health Risk Behaviours/ or exp Self Concept/ or exp Perception/ or (risk adj3 behavio*).mp. or risk taking.mp. or (hazard* adj2 behavio*).mp. or (danger* adj2 behavio*).mp. or risk appraisal.mp. or risk evaluation.mp. or self-perception.mp. or self-perceived risk.mp. or self-perceived.mp. or (risk* adj3 estimate*).mp. or (risk* adj2 judgment*).mp. or (risk* adj3 perception*).mp. or (perceived adj3 risk*).mp. or perceived ability.mp. or (risk adj3 awareness).mp. or circumstance*.mp. or impulsiv*.mp. or sensation seeking.mp.	784,927
4	1 and 2 and 3	3,400
5	limit 4 to (yr="2000 -Current") and (english or french))	2,691

OVID AMED (02/07/2020)		
#	**Searches**	**Results**
1	exp Aged/ or (older adult* or elder* or senior*).mp.	19,165
2	exp Accidental Falls/ OR fall*.mp. OR slip*.mp. OR trip*.mp.	4,863
3	exp Choice Behaviour/ or exp Self Concept/ or Perception/ or (risk adj3 behavio*).mp. or risk taking.mp. or (hazard* adj2 behavio*).mp. or (danger* adj2 behavio*).mp. or risk appraisal.mp. or risk evaluation.mp. or self-perception.mp. or self-perceived risk.mp. or self-perceived.mp. or (risk* adj3 estimate*).mp. or (risk* adj2 judgment*).mp. or (risk* adj3 perception*).mp. or (perceived adj3 risk*).mp. or perceived ability.mp. or (risk adj3 awareness).mp. or circumstance*.mp. or impulsiv*.mp. or sensation seeking.mp.	9,070
4	1 and 2 and 3	134
5	limit 6 to (yr="2000 -Current") and (english or french))	112

OVID EMBASE (02/07/2020)		
#	**Searches**	**Results**
1	exp Aged/ or (older adult* or elder* or senior*).mp.	3,134,382
2	exp Accidental Falls/ OR fall*.mp. OR slip*.mp. OR trip*.mp.	909,781
3	exp High Risk Behaviour/ or Self Concept/ or Perception/ or (risk adj3 behavio*).mp. or risk taking.mp. or (hazard* adj2 behavio*).mp. or (danger* adj2 behavio*).mp. or risk appraisal.mp. or risk evaluation.mp. or self-perception.mp. or self-perceived risk.mp. or self-perceived.mp. or (risk* adj3 estimate*).mp. or (risk* adj2	468,336

	judgment*).mp. or (risk* adj3 perception*).mp. or (perceived adj3 risk*).mp. or perceived ability.mp. or (risk adj3 awareness).mp. or circumstance*.mp. or impulsiv*.mp. or sensation seeking.mp.	
4	1 and 2 and 3	2,642
5	limit 6 to (yr="2000 -Current") and (english or french))	2,304

OVID APA PsychInfo (02/07/2020)		
#	**Searches**	**Results**
1	exp Geriatric Patients/ or exp Geriatrics/ or (older adult* or elder* or senior*).mp.	149,062
2	exp Falls/ or fall*.mp. or trip*.mp. or slip*.mp.	70,599
3	exp Risk Taking/ or Risk Perception/ or (risk adj3 behavio*).mp. or risk taking.mp. or (hazard* adj2 behavio*).mp. or (danger* adj2 behavio*).mp. or risk appraisal.mp. or risk evaluation.mp. or self-perception.mp. or self-perceived risk.mp. or self-perceived.mp. or (risk* adj3 estimate*).mp. or (risk* adj2 judgment*).mp. or (risk* adj3 perception*).mp. or (perceived adj3 risk*).mp. or perceived ability.mp. or (risk adj3 awareness).mp. or circumstance*.mp. or impulsiv*.mp. or sensation seeking.mp.	172,361
4	1 and 2 and 3	235
5	limit 6 to (yr="2000 -Current") and (english or french))	206

EBSCOhost CINAHL (02/07/2020)		
#	**Searches**	**Results**
1	OR (MH "Aged+") OR "elder*" OR "older adult*" OR "senior*"	936,745
2	(MH "Accidental Falls") OR "fall*" OR "trip*" OR "slip*"	100,228
3	(MH "Risk Taking Behaviour+") OR (MH "Perception+") OR (MH "Self Concept+") OR "danger* behavio*" OR "hazard* behavio*" OR "risk* behavio*" OR "behaviour* risk*" OR "health risk behavio*" OR "risk appraisal" OR "risk taking" OR "perceived risk" OR "self-perceived risk" OR "self-perception" OR "risk perception" OR "risk judgement*" OR "risk evaluation" OR "perceived ability" OR "circumstance*" OR "impulsiv*" OR "sensation seeking"	248,679
4	1 and 2 and 3	2,344
5	Limiters – publication date: 2000-2020; Language: english, french	2,154

EBSCOhost AgeLine (02/07/2020)		
#	**Searches**	**Results**
1	older adults or elderly or seniors or geriatrics or older people or aged or senior citizens	92,293
2	accidental falls or fall* or trip* or slip*	5, 941

3	risk taking or risk* behavio* or risk-taking behavio* or danger* behavio* or hazard* behavio* or health risk behavio* or risk appraisal or perceived risk or self-perceived risk or self-perceived or self-perception or risk perception or risk judgement or risk evaluation or perceived ability or circumstance or impulsiv* or sensation seeking	3, 215
4	1 and 2 and 3	270
5	Limiters – publication date: 2000-2020	182

Data Extraction Sheets

Sheet 1. Characteristics of Studies

Author (Year)	Country	Methods	Study Aim	Population			Falls Collection	Risk-Taking			
				Sample Size	% Female	Age		Behaviour	Propensity	Attitudes	Appraisal

Sheet 2. Risk-Taking Assessment Details

Author (Year)	Type/Theme	Assessment Description	Assessment Rationale/Reasoning	Study Results

Sheet 3. Risk-Taking Behaviour Details

Author (Year)	Perspective of Risk/Risk-Taking Behaviour	Risk-Taking Behaviours	Notes/Comments

Sheet 4. Factors Associated with Risk-Taking

Author (Year)	Risk-Taking Propensity	Risk Appraisal	Risk Attitudes	Other	Notes/Comments

CHAPTER FOUR

THE RELATIONSHIP BETWEEN FEAR OF FALLING AND FUNCTIONAL ABILITY FOLLOWING A MULTI-COMPONENT FALL PREVENTION PROGRAM: AN ANALYSIS OF CLINICAL DATA

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The relationship between fear of falling and functional ability following a multi-component fall prevention program: an analysis of clinical data

ABSTRACT

Purpose: The first objective of this study was to determine if participants who completed a multi-component fall prevention program showed an improved physical function and decreased fear of falling (FoF). The second objective of this study was to explore the relationship between physical function and level of FoF.

Methods: Adults (mean age = 76 years) who participated in the Building Balance program (BBP) between 2011-2020 were assessed with the Berg Balance Scale (BBS), Timed-Up and Go (TUG), 30-second chair stand (30 CST), Functional Reach (FR), Gait Speed, Single-Item FoF, and short Falls Efficacy Scale – International (short FES-I) at baseline and at program completion (6 weeks). Repeated measures ANOVA controlling for age and sex were performed to assess change from baseline. Linear regressions were conducted to evaluate how physical function explained variations in levels of FoF.

Results: There were significant improvements between pre- and post-program BBS scores ($p < 0.001$), TUG times ($p < 0.001$), 30 CST repetitions ($p < 0.001$), FR distance ($p < 0.001$), gait speed ($p < 0.001$), single item-FoF score ($p < 0.001$), and short FES-I score ($p < 0.001$). Age, sex, and pre-program gait speed explained variations in log transformed pre-program short FES-I scores (Adjusted $R^2 = 0.19$). Variations in log transformed post-program short FES-I scores (p <

0.001) were explained by age, sex, post-program TUG times and post-program FR distance.

Conclusion: A community-based exercise and education fall prevention program improves physical function and decreases level of FoF. We found a small association between physical function and level of FoF that was similar between pre- and post-program conditions. A high prevalence of FoF in adults < 65 years was also observed.

Key Words: fall prevention, exercise, education, fear of falling

INTRODUCTION

One in three older adults experience a fall each year.[1,2] Falling in older age can result in severe physical consequences, including joint and soft tissue injuries, fractures, chronic pain, and disability.[1,3,4] In addition to falls, 20 to 85% of community-dwelling older adults, with or without a history of falls, report having a fear of falling (FoF).[5] FoF has been associated with self-imposed activity restriction, reduced social interaction, and physical deconditioning, increasing the risk of future falls and reducing quality of life.[5–8] As the impact of falls and FoF is expected to increase with the ageing population, communities need to implement effective interventions to reduce FoF and prevent future falls.[1,9,10]

Exercise-based programs are the most recommended and effective strategy to reduce falls in community-dwelling older adults.[11–13] Specifically, a high quality systematic review identified moderate quality evidence that interventions consisting of balance and functional exercises with resistance training demonstrate the greatest reduction in fall rate compared to control interventions (i.e., non-active intervention, or usual care) (rate ratio, 0.66, 95% CI 0.50, 0.88).[14] It is suggested that exercise interventions likely reduce an individual's fall risk by improving functional capacity, thereby reducing their vulnerability to situational challenges.[14]

Despite a large number of exercise-based interventions developed to decrease FoF, the evidence to support these interventions is mixed.[15–17] Fear is a normal response to an active or imagined threat that exists on a continuum – ranging from 'no fear' to 'ptophobia' (i.e., phobic FoF).[18] Active threats include previous fall experience or recognition of reduced functional abilities. Imagined threats may be influenced by psychological factors such as anxiety and/or depression.[5,18–20] Impaired physical function such as decreased muscle strength, balance impairments, and reduced mobility have been identified risk factors for FoF.[21–24] However, studies that have established this relationship have treated FoF measures as a discrete variable (i.e., fear vs no fear). For example, Park et al., [21] classified participants with Fall Efficacy Scale – International (FES-I) scores <23 as having no FoF, and those with a score of ≥ 23 as having FoF. These authors found individuals with FoF had lower Short Physical Performance Battery Scores (9.4 vs 10.9, $p < 0.001$), Timed-Up and Go times (15.1s vs 12.0s, $p < 0.001$), and grip strength (23.5lbs vs 30.5lbs, $p < 0.001$) compared those without FoF.[21] As FoF exists on a continuum, it is important for researchers to evaluate relationships between physical function and FoF across the continuum to provide a detailed understanding of this concept.

This study aimed to determine whether participants' performance-based measures of balance, lower extremity strength, postural stability, mobility, and level FoF improved from pre- and post- program participation in a community-based multi-component fall prevention program. A secondary purpose of this study was to investigate the relationship between physical function and level of

FoF in community-dwelling older adults before and after participation in the same program.

RESEARCH QUESTIONS

1. Does participating in a six-week multi-component fall prevention program improve physical function and fear of falling in community-dwelling adults?
2. What association exist between physical function and level of fear of falling before and after participating in a community-based multi-component fall prevention program?

METHODS

To address the first research question, a quasi-experimental one-group pre-test-post-test design using clinical data collected as part of a community-based multi-component fall prevention program – the Building Balance Program (BBP), was applied. The Template for Intervention Description and Replication (TIDieR),[25] and the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) guided the reporting of this study. To address the second research question, a cross-sectional evaluation of baseline and longitudinal clinical data from 36 sequential groups between 2011-2020 collected as part of the BBP was applied. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement[26] guided the reporting of the second research question. This use of clinical data for this study was approved by the Hamilton Integrated Research Ethics Board (Project number 9486-C).

The Building Balance Program (BBP)

The BBP is an evidence-informed fall prevention program designed to address multiple modifiable risk factors to reduce the rate of injurious falls in the North Simcoe, Muskoka community, Ontario, Canada.[27] The BBP is delivered twice weekly for six weeks, in a group format at a local YMCA. The program consists of 80 minutes of strength and balance training, followed by a 40-minute fall prevention education session discussing modifiable fall risk factors.[27] All exercise sessions are supervised by a physiotherapist, a physiotherapy assistant and four to five trained volunteers and exercise parameters (e.g., intensity) are individually tailored.[27] Exercise bands, dumbbells, and ankle weights are used for resistance exercises; stability discs and balance pads are used for stability exercises and grab bars and gait belts were used to provide balance support.[27] A variety of healthcare providers (i.e., occupational therapist, dietitian, registered nurse) lead the education sessions.[27] Participants are also provided with a pamphlet that describes a home exercise program.

Study Population

This study included all cases from the BBP dataset that had a least one post-program outcome measure.[27] Cases that corresponded to a participant's second enrollment in the BBP were excluded from the analysis. Individuals were referred to the BBP by primary health care providers via a standardized referral form.[27] The referral form was reviewed by a physiotherapist employed by the South

Georgian Bay Community Health Center to determine if an individual was eligible for participation.[27] Inclusion criteria for the BBP included self-reported FoF or self-report of one or more near falls in the past three months; or one or more falls in the past year.[27] Participants were excluded from the BBP if they were medically unstable for exercise, had a score of <26/30 on the Montreal Cognitive assessment, or a score of < 35 on the Berg Balance Scale (BBS), or weighed > 250lbs.[27]

Study Variables

Prior to starting the BBP, all participants completed a 90-minute individual assessment with the same physiotherapist who ran the exercise sessions.[27] This assessment included gathering demographic characteristics and five performance-based measures to evaluate static and dynamic balance, lower extremity strength, gait ability, and two self-reported measures of FoF (Table 1).[27] Immediately after completing the six-week program, participants completed a second assessment with the same physiotherapist. This assessment included the five performance-based measures and two self-reported measures of FoF.[27]

Single Item Fear of Falling (FoF)

BBP participants rated overall FoF on an 11-point numeric scale with response options ranging from 0 (no fear of falling) to 10 (extreme fear of falling).[27] Psychometric properties for the 11-point numeric scale have not been assessed;

however, the 10-point numeric scale has demonstrated fair test-retest reliability (ICC 0.57, 95% CI 0.49, 0.64).[28]

Short Falls Efficacy Scale – International

The shortened version of the FES-I is a 7-item self-reported outcome measure that evaluates FoF during activity.[29] Response options range from 1 (not at all concerned) to 4 (very concerned), with total scores ranging from 7 (no concern about falling) to 28 (severe concern about falling).[29] The short FES-I demonstrated high test-retest reliability (Cronbach's alpha 0.92, $ICC_{1,1}$ = 0.83) and correlation with the FES-I (Spearman Rho = 0.87) in community-dwelling older adults.[29]

Berg Balance Scale

The Berg Balance Scale (BBS) is a 14-item performance-based measure used to assess an individual's ability to maintain balance.[30] Each task is graded on a 5-point ordinal scale, with standardized criteria for each task.[30] Total scores range from 0 to 56, with lower scores indicating greater balance impairments.[30] High inter-rater relative reliability (ICC = 0.98, 95% CI = 0.97, 0.99) and intra-rater (ICC = 0.97, 95% CI = 0.96, 0.98) has been identified for the BBS with a variety of clinical populations.[31]

Timed-Up and Go (TUG)

The TUG test is a performance-based measure that assesses a combination of mobility, balance, and gait ability.[32] The TUG evaluates the time it takes an individual to rise from a chair, walk 3m, turn and walk back to the chair and return to a seated position, with a faster time indicates greater mobility.[32] Community-based studies with older adults demonstrated high inter-rater and intra-rater reliability (ICC ranging from 0.93-0.99).[33] Fall prevention guidelines commonly recommend the TUG as a tool to screen for fall risk in older adults.[34,35]

30-second chair-stand test (30 CST)

The 30 CST is a performance-based measure that assesses lower extremity strength in older adults.[36] The 30 CST evaluates the number of times an individual can rise from a chair in 30 seconds.[36] It has demonstrated high test-retest reliability (R = 0.89, 95% CI = 0.79, 0.93) and inter-rater reliability (R = 0.91, 95% CI = 0.81, 0.94) in healthy community-dwelling older adults.[36] A moderate correlation between the 30 CST and weight-adjusted one-repetition maximum leg press (r = 0.77, 95% CI = 0.64, 0.85) has been observed in healthy community-dwelling older adults, validating the 30 CST as a measure of lower extremity strength.[36]

Functional Reach (FR)

The FR test is a performance-based measure that assesses an individual's dynamic stability.[37] It measures the maximal distance (in inches) an individual can reach forward while maintaining a fixed base of support in a standing position.[37] The FR test has demonstrated high inter-rater reliability (ICC = 0.99) and intra-rater reliability (ICC = 0.97) in community-dwelling older adults.[38]

Gait Speed

Gait speed is a performance-based measure of functional mobility and gait ability over a short distance.[39] The time for an individual to walk 10m is used to calculate the gait speed in meters per second.[27] It has demonstrated high test-retest reliability (ICC = 0.98, 95% CI = 0.96, 0.99)[39] and inter-rater reliability (ICC > 0.90)[40] in community-dwelling older adults.

Statistical Analysis

Data analysis was conducted using STATA version 16.0 for Windows (STATACorp LLC, College Station, Texas). Descriptive statistics were generated and reported as means and standard deviations or median and interquartile range for each variable, as indicated. Comparisons among measures, pre- and post-program participation were assessed using repeated measures ANOVA controlling for age and sex. All data were checked for normality of the differences by exploring histograms, Shapiro-Wilk test for normality, skewness, and kurtosis values.

We performed linear regression to determine the extent to which pre- program physical performance measures explained variations in pre-program FoF; and post-program physical performance measures explained variations in post-FoF (i.e., single item FoF scores and Short FES-I scores) (Figure 1). One participant had a pre-program TUG time of 80-seconds, which was significantly higher than the rest of the sample and found to be an influential point. This participant's data was removed from all analyses. Pearson correlation analyses were used to identify highly correlated variables between the physical performance measures. Variables with $r > 0.8$ were not included in the same regression model.[41] For each regression model, univariate linear regression analyses were used to test whether selected independent variables were associated with the dependent variable. Variables with $p < 0.2$ in the univariate analyses were included in a regression analysis conducted using backward elimination. Candidate variables were removed one at a time until all variables met the significance level of 0.05. As previous research demonstrated age and sex differences in fall rates and FoF,[19,42–46] these variables were forced into the final regression model. In addition, interactions between sex and age with BBS scores, TUG times, 30 CST repetitions, FR distances, and gait speed were constructed to test for effect modifiers. Computer forward and backward stepwise regressions were conducted to confirm the results. A residual-versus-fitted plot and the Breusch-Pagan chi-square test verified the assumption of homoskedasticity. Multicollinearity was assessed using the Variance Inflation Factor. Distribution of the residuals was assessed using histograms and the Shaprio-Wilk test. Influential points were identified based on leverage, residual, and Cook's distance and considered for removal. Robust regressions were conducted when assumptions were not met despite data transformation.

RESULTS

A total of 348 participants enrolled in the BBP between January 2011 and January 2020. Sixty-one participants (17.5%) did not complete a post-program assessment, and nine participants completed two cycles of the BBP. The nine cases that corresponded to a participant's second enrollment in the BBP were excluded from the statistical analyses, resulting in 287 participants included in this study (Figure 2). The mean age of this sample was 76 years (SD = 9 years, min = 51 years, max = 95 years), and the majority of participants were female (n = 175, 60.98%) (Table 1).

After controlling for age and sex, individuals enrolled in the BBP demonstrated a statistically significant improvement between pre- and post-program for all evaluated outcomes: BBS scores ($F[1, 286] = 435.36$, $p < 0.001$), TUG times ($F[1, 285] = 142.41$, $p < 0.001$), 30 CST repetitions ($F[1, 277] = 279.37$, $p < 0.001$), FR distance ($F[1, 284] = 193.67$, $p < 0.001$), gait speed ($F[1, 282] = 166.87$, $p < 0.001$), single item-FoF score ($F[1, 285] = 77.78$, $p < 0.001$), and short FES-I score ($F[1, 285] = 95.45$, $p < 0.001$). Table 2 presents the pre- and post-program outcome measure scores for each age and sex group.

Factors Associated with Fear of Falling

Pre-Single Item FoF

Univariate linear regression analysis showed age, sex, pre-program BBS, pre-program TUG time, pre-program 30 CST repetitions, pre-FR distance, and pre-program gait speed were candidate variables ($p < 0.2$) for the multivariate pre-program single item FoF regression model (Table 2). The multivariate linear regression showed age ($\beta = -0.10$, 95% CI = −0.13,−0.07, $p < 0.001$), sex ($\beta = -0.91$, 95% CI = −1.45, −0.37, $p = 0.001$), pre-program BBS scores ($\beta = -0.13$, 95% CI = −0.19, −0.08, $p < 0.001$), and pre-program 30 CST repetitions (−0.09, 95% CI = −0.17, −0.005, $p = 0.04$) explained 24.6% of variations in pre-program single item FoF ($F [4, 273] = 23.53$, $p < 0.001$). All regression assumptions were met.

Post-Single Item FoF

Post-program FoF scores were transformed using a square root transformation to adjust for skewness. Univariate linear regression analysis showed age, post-program BBS scores, post-program TUG time, post-program 30 CST repetitions, pre-FR distance, and pre-program gait speed were candidate variables ($p < 0.2$) for the multivariate post-program single item FoF regression model (Table 2). A multivariate robust regression was conducted for post-program FoF to adjust for heteroskedasticity. When sex is constant, variations in post-program squared FoF scores ($F[5,277] = 10.41$, $p < 0.001$) were explained by age ($\beta = 0.05$, 95%

CI = 0.002, 0.09), post-program TUG times (β = 0.06, 95% CI = 0.04, 0.09), and post-program FR distance (β = 0.39, 95% CI = 0.10, 0.69) with a two-way interaction between age and post-program FR distance (β = −0.005, 95% CI = −0.009, −0.002).

Pre FES-I

As the short FES-I scores for pre- program participation were positively skewed, a logarithmic transformation was applied. Univariate linear regression analysis showed age, pre-program BBS score, pre-program TUG time, pre-program 30 CST repetitions, pre-FR distance, and pre-program gait speed were candidate variables ($p < 0.2$) for pre-program short FES-I scores. After controlling for sex, the multivariate linear regression identified age (β = −0.14, 95% CI = −0.20, −0.08), and pre-program gait speed (β = −0.49, 95% CI = −0.64, −0.34) to explain variations in log transformed pre-program short FES-I scores (Adjusted R^2 = 0.188, F [3, 279] = 22.76, $p < 0.001$). In other words, a 13% decrease in short FES-I scores can be explained by a one-year increase in age when holding the remaining explanatory variables constant. A 3.8% decrease in pre-program short FES-I scores can be explained by a 0.1m/s increase in gait speed when holding the remaining explanatory variables constant. All regression assumptions for the final model were met.

Post FES-I

A logarithmic transformation was applied to post-program to adjust for positive skewness a logarithmic transformation was applied. Univariate linear regression analysis showed age, post-program BBS score, post-program TUG time, post-program 30 CST repetitions, post-FR distance, and post-program gait speed were candidate variables ($p < 0.2$) for post-program short FES-I scores. When sex is constant, variations (Adjusted $R^2 = 0.170$, $F [4, 278] = 15.40$, p-value < 0.001) in log transformed post-program short FES-I scores were explained by age ($\beta = -0.007$, 95% CI = −0.01, −0.004), post-program TUG times ($\beta = 0.02$, 95% CI = 0.01, 0.03), and post-program FR distance ($\beta = -0.02$, 95% CI = −0.03, −0.003). When holding all other explanatory variables constant, a one-year increase in age can explain a 0.7% decrease in post-program short FES-I scores. A 2% increase in post-program short FES-I can be explained by a one-second increase in TUG times; and a one-centimeter increase in FR distance can explain a 2% decrease in short FES-I scores. All assumptions required for the analysis were met.

DISCUSSION

This study assessed whether participants' physical performance and level of FoF improved following participation in a six-week multi-component fall prevention program. The secondary aim of this study was to evaluate the extent to which a participant's physical performance explains variations in the level of FoF. Our analysis identified significant improvements between pre- and post-program participation across five performance-based measures of physical function and two self-report measures of FoF. Overall, the regression analyses in this study showed weak associations between FoF measures and physical capacity in community-dwelling adults. Interestingly, our results also demonstrated a negative association between age and level of FoF - meaning younger age was associated with higher levels of FoF in the BBP population.

A secondary finding of this study identified a ceiling effect with post-program BBS scores. At baseline, 5.9% of participants had the highest possible BBS score, which increased to 29.6% at post-program assessment. This finding is consistent with previous studies showing a ceiling effect in community-dwelling older adults, which suggests the BBS may not be the most appropriate test for community-dwelling older adults.[47,48] The Mini-BESTest, is a 14-item clinical tool that evaluates an individual's dynamic balance control and includes dual-task items such as walking while performing a cognitive task.[49] Mini-BESTest demonstrates high test-retest reliability (ICC = 0.96, 95% CI 0.94, 0.99), high interrater reliability (ICC = 0.98, 95% CI 0.97, 0.99), and is highly correlated with BBS scores (r = 0.85, 95% CI = 0.78, 0.90).[49] Most importantly, the Mini-BESTest appears to have lower ceiling effects than the BBS,[49] suggesting the Mini-BESTest may be a more appropriate test for community-dwelling older adults.

In the BBP sample analyzed for this paper, 95% of participants reported having a FoF (score > 0 on the single item-FoF scale, or score >7 on the short FES-I), higher than most reports of FoF in community-dwelling older adults.[50] The BBP inclusion criteria may partially explain these findings – as they include older adults with self-reported FoF. Our regression analysis found no evidence of sex as an explanatory variable for FoF. However, this finding is in contrast to other findings. For example, Friedman et al.,[20] found female gender was a strong predictor of developing FoF (odds ratio 2.53, 95% CI = 1.85-3.45). Surprisingly, FoF was highest among the youngest participants in this study despite better performance in physical function measures. This finding suggests that FoF may be influenced by other factors. Peeters et al.,[51] suggested FoF can be explained through learning mechanisms in movement-related fears which involves cognitive, emotional, and physiological factors. However, more research is needed to validate Peeters et al.,[51] conceptual framework.

We found a small association between physical function and level of FoF at baseline and post-program participation. These findings are not surprising, as fear develops as a response to threats, active or imagined,[18] which is associated with both physiological and psychological factors.[52,53] Although FoF can develop from a recognition of diminished physical function, this process assumes that an individual's appraisal of their abilities aligns with their actual abilities.[52] Previous studies have demonstrated a portion of older adults tend to overestimate their falls risk.[54,55] Delbaere et al.,[54] found overestimation of fall risk was associated with depressive symptoms ($p = 0.029$), neurotic personality traits ($p = 0.026$), and decreased executive functioning ($p = 0.010$). This suggests an individual's appraisal of their abilities may be partially mediated by psychological factors such as depression.[54] In addition, previous experience may have an effect on level of FoF, particularly if an individual experienced severe consequences from their fall (e.g., falling at home and being unable to get up).[18] Future research could explore whether the severity of previous falls influences the level of FoF reported.

The observed association between physical performance and level of FoF was similar between baseline and post-program participation. For example, variation in log transformed pre-program short FES-I scores decreased slightly (from 18.8% to 17.0%) at the post-program assessment. However, the physical performance measures that explained variations in FoF were different between pre-program and post-program. After controlling for sex, pre-program short FES-I scores were explained by age, and pre-program gait speed; whereas, post-program short FES-I score were explained by age, post-program TUG times, and post-program FR distance. It is unclear why different measures of physical function explained variations in short FES-I scores at baseline and post-program. Although improvements in physical function may have led to reduced FoF, there is another possible explanation for this result. As the BBP included progressive static and dynamic stability exercises such as walking across an uneven surface, it is possible this exposure increased balance confidence and reduced fear associated with this activity, in conjunction with improvements in balance ability. This approach is similar to one described by Bhala et al.,[18] in their initial conceptualization of FoF, where participants were gradually exposed to fearful activities. As FoF is associated with psychological factors, psychotherapeutic interventions such as graded exposure or cognitive-behavioural therapy may be beneficial for individuals with excessive FoF. Further evaluation into the psychological components of FoF is warranted to determine characteristics of individuals who could benefit from psychotherapeutic interventions.

LIMITATIONS

Limitations of this study include the data collection by the physiotherapist who oversaw the management of the program, which could have led to bias in the assessment of the results. Secondly, data on fall history, depression, cognitive function, and self-perception of health and physical function was not collected as part of the BBP and, therefore, were not available for our study. As a result, we could not determine how these factors influence the relationship between physical function and FoF. In addition, as the BBP did not collect prospective data on falls, we could not determine to what extent this program prevents falls and injurious falls as the BBP did not collect data on falls.

CONCLUSION

Participation in the BBP, a community-based fall prevention program designed to address physical function and FoF in community-dwelling older adults, resulted in improved physical function and reduced FoF. Weak associations between FoF and performance-based measures of balance, mobility, gait, and lower extremity strength were also observed, suggesting that other factors may be involved with FoF.

KEY MESSAGES

What is known on this topic?

Fear of falling and falls have a complex bi-directional relationship and share several risk factors such as age, sex, balance and gait impairments, and decreased muscle strength.[19–23,56] However, evidence to support physical function as a risk factor for FoF is mixed.[5,52–54] Exercise-based interventions are effective at reducing falls[14] and may reduce an individual's level of FoF.[15–17]

What this study adds?

This study showed an evidence-informed exercise and education community fall prevention program, delivered twice per week for six weeks, improved older adults' mobility, lower extremity muscle strength, gait and balance, and reduced levels of FoF. A ceiling effect with BBS scores was observed, suggesting the BBS may not be the most appropriate assessment tool for community-dwelling older adults.

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Table 1. Distribution of Participants by Age and Sex

	Group	**Males**	**Females**
Total	N = 287	N = 112	N = 175
≤ *69 years*	N = 66	N = 16	N = 50
70 – 79 years	N = 120	N = 49	N = 71
≥ *80 years*	N = 101	N = 47	N = 54

Table 2. Participant Baseline and Post-program outcome measures

Outcome Measure	Age Categories	Mean (SD)	
		Pre-Program	Post-Program
Berg Balance Scale (score)	**Group**	**50 (7)***	**54 (5)***
	Females	50 (8)*	55 (4)*
	≤ 69 years	52 (6)*	55 (3)*
	70 – 79 years	51 (9)*	55 (4)*
	≥ 80 years	48 (5)*	53 (5)*
	Males	49 (6.5)*	53 (4.5)*
	≤ 69 years	51 (8)*	56 (3)*
	70 – 79 years	49 (6)*	54 (5)*
	≥ 80 years	48 (6)*	52 (5)*
Timed-Up and Go (seconds)	**Group**	**12.79 (5.11)***	**10.56 (4.04)***
	Females	12.61 (5.11)*	10.34 (4.31)*
	≤ 69 years	11.76 (4.28)*	10.01 (3.81)*
	70 – 79 years	13.22 (6.74)*	9.75 (4.49)*
	≥ 80 years	13.94 (5.60)*	11.55 (3.47)*
	Males	12.84 (4.41)*	11.13 (3.70)*
	≤ 69 years	11.56 (6.74)*	9.55 (4.16)*
	70-79 years	12.79 (4.15)*	10.59 (3.47)*
	≥ 80 years	13.07 (3.87)*	11.39 (2.97)*
30 Chair stand tests (repetitions)	**Group**	**10.4 (3.8)**	**13.1 (4.1)**
	Females	10.4 (3.6)	13.2 (3.9)
	≤ 69 years	10.3 (3.7)	13.3 (3.6)
	70 – 79 years	10.8 (3.8)	13.4 (4.3)
	≥ 80 years	9.8 (3.1)	12.7 (3.7)
	Males	10.5 (4.1)	13.0 (3.9)
	≤ 69 years	11.9 (6.2)	15.9 (5.2)
	70 – 79 years	10.8 (3.9)	13.5 (4.5)
	≥ 80 years	9.6 (3.1)	11.5 (3.4)
Functional Reach (in)	**Group**	**9.4 (2.6)**	**11.1 (2.5)**
	Females	9.2 (2.5)	11.0 (2.5)

	≤ 69 years	10.0 (3.1)	11.8 (2.5)
	70 – 79 years	9.1 (2.4)	11.0 (2.5)
	≥ 80 years	8.7 (1.9)	10.4 (2.3)
	Males	9.8 (2.8)	11.3 (2.5)
	≤ 69 years	11.1 (4.3)	12.3 (3.3)
	70 – 79 years	10.1 (2.4)	11.5 (2.2)
	≥ 80 years	9.1 (2.2)	10.8 (2.4)
Gait Speed (m/s)	**Group**	**0.94 (0.24)**	**1.04 (0.23)**
	Females	0.94 (0.25)	1.05 (0.23)
	≤ 69 years	0.98 (0.24)	1.10 (0.22)
	70 – 79 years	0.95 (0.29)	1.06 (2.66)
	≥ 80 years	0.88 (0.20)	0.98 (0.17)
	Males	0.96 (0.22)	1.03 (0.23)
	≤ 69 years	1.06 (0.29)	1.19 (0.25)
	70 – 79 years	0.97 (0.20)	1.05 (0.23)
	≥ 80 years	0.91 (0.21)	0.96 (0.20)
Single Item Fear of Falling (score)	**Groups**	**4 (3)***	**3 (2)***
	Females	4 (4)*	3 (3)*
	≤ 69 years	6 (4)*	3 (3)*
	70 – 79 years	4 (4)*	3 (2)*
	≥ 80 years	3 (3)*	3 (3)*
	Males	3 (3)*	2.5 (2.5)*
	≤ 69 years	4.5 (4.5)*	2 (1.5)*
	70 – 79 years	3 (3)*	3 (2)*
	≥ 80 years	3 (3)*	2 (3)*
Short Falls Efficacy Scale – International (score)	**Group**	**13 (6)***	**11 (4)***
	Females	13 (7)*	11 (4)*
	≤ 69 years	15 (5)*	11.5 (3)*
	70 – 79 years	13 (7)	10 (3)*
	≥ 80 years	12 (6)*	10 (5)*
	Males	13 (6)*	10 (4)*
	≤ 69 years	14 (7.5)*	10 (2.5)*

	70 – 79 years	13 (6)*	11 (4)*
	≥ *80 years*	12 (4)*	10 (4)*

*Reported as Median and Interquartile ranges due to skewness

Table 3. Factors associated with pre and post single-item Fear of Falling (FoF) scores

Dependent Variable	Explanatory Variables						Model	
	Var.	Coef.	t	p-value	95% Conf. Interval		F-statistic	Adj. R^2
					Lower	Upper		
Pre-FoF	Univariate Analyses							
	Age	−0.09	−5.54	< 0.001§	−0.13	−0.06	F(1, 284) = 30.66, p < 0.001§	0.09
	Sex	−1.06	−3.32	0.001§	−1.68	−0.43	F(1, 284) = 11.05, p = 0.001§	--
	Pre-BBS	−0.14	−5.15	<0.001§	−0.19	−0.08	F(1, 284) = 26.55, p < 0.001§	0.08
	Pre-TUG	0.17	5.16	<0.001§	0.10	0.24	F(1, 283) = 26.63, p < 0.001§	--
	Pre- 30 CST	−0.17	−4.34	<0.001§	−0.25	−0.09	F(1, 276) = 18.82, p < 0.001§	0.06
	Pre-FR	−0.17	−2.91	0.004§	−0.28	−0.05	F(1, 282) = 8.47, p < 0.001§	0.03
	Pre-Gait Speed	−2.68	−4.32	<0.001§	−3.90	−1.46	F(1, 281) =18.65, p < 0.001§	0.06
	Multivariate Analysis							
	Age	−0.10	−6.20	< 0.001§	−0.13	−0.07	F(4, 273) =23.53, p < 0.001§	0.25
	Sex	−0.91	−3.44	0.001§	−1.45	−0.37		
	Pre-BBS	−0.13	−4.61	< 0.001§	−0.19	−0.08		
	Pre-30 CST	−0.09	−2.09	0.04§	−0.03	−0.008		
Post-FoF**	Univariate Analyses							
	Age	−0.01	−1.98	0.049§	−0.19	−0.001	F(1, 283) = 3.91, p = 0.048§	--
	Sex	−0.13	−1.60	0.111	−0.30	0.03	F(1, 283) = 2.55, p = 0.11	--
	Post-BBS	−0.06	−4.96	<0.001§	−0.08	−0.04	F(1, 283) = 24.64, p < 0.001§	--
	Post-TUG	0.06	5.59	<0.001§	0.04	0.08	F(1, 282) = 31.28, p < 0.001§	--
	Post- 30 CST	−0.04	−4.63	<0.001§	−0.06	−0.03	F(1, 277) = 21.48, p < 0.001§	--
	Post-FR	−0.04	−2.54	0.012§	−0.08	−0.009	F(1, 282) = 6.44, p = 0.012§	--
	Post-Gait Speed	−0.64	−3.62	<0.001§	−0.97	−0.29	F(1, 280) = 13.09, p < 0.001§	--

	Multivariate Analysis							
	Age	0.05	2.08	0.04[§]	0.002	0.09	F(5, 277) = 10.41, p < 0.001[§]	--
	Sex	−0.10	−1.15	0.253	−0.26	0.07		
	Post-TUG	0.06	5.28	< 0.001[§]	0.04	0.09		
	Post-FR	0.39	2.66	0.008[§]	0.10	0.69		
	Age + Post-FR	−0.005	−2.79	0.006[§]	−0.009	−0.002		

** square root transformation

[§] Indicates significance at $p < 0.05$

-- indicates a robust regression which does not provide a R squared.

Var. = variable, Coef. = non-standardized coefficient, std. err. = standard error, t = t-statistic, conf. interval = confidence interval, adj R^2 = adjusted R squared, pre-BBS = pre-program berg balance scale score, pre-TUG = pre-program timed-up and go time, pre- 30 CST = pre-program 30 seconds chair stand repetitions, pre-FR = pre-program functional reach distance, pre-gait speed = pre-program gait speed, post-BBS = post-program berg balance scale score, post-TUG = post-program timed-up and go time, pre- 30 CST = post-program 30 seconds chair stand repetitions, post-FR = post-program functional reach distance, post-gait speed = post-program gait speed

Table 4. Factors associated with pre and post short Falls Efficacy Scale – International scores

Dependent Variable	Explanatory Variables						Model	
	Var.	Coef.	t	p-value	95% Conf. Interval		F-statistic	Adj. R^2
					Lower	Upper		
Pre-Short FES-I*	Univariate Analyses							
	Age	−0.14	−4.86	<0.001§	−0.20	−0.08	F(1, 284) = 21.96, p < 0.001§	0.07
	Sex	0.61	−1.14	0.254	−1.66	0.44	F(1, 284) = 1.67, p = 0.20	0.01
	Pre-BBS	−0.25	−5.42	<0.001§	−0.33	−0.16	F(1, 284) = 29.29, p < 0.001§	0.09
	Pre-TUG	0.20	5.55	<0.001§	0.20	0.41	F(1, 282) = 17.12, p < 0.001§	0.05
	Pre- 30 CST	−0.28	−4.06	<0.001§	−0.41	−0.14	F(1, 276) = 17.37, p < 0.001§	0.06
	Pre-FR	−0.34	−3.44	0.001§	−0.53	−0.14	F(1, 282) = 12.27, p < 0.001§	0.04
	Pre-Gait Speed	−5.65	−5.34	<0.001§	−7.73	−3.57	F(1, 281) = 27.68, p < 0.001§	0.09
	Multivariate Analysis							
	Age	−0.13	−5.97	< 0.001§	−0.02	−0.008	F(3, 279) =22.76, p < 0.001§	0.19
	Sex	−0.006	−0.16	0.874	−0.08	0.07		
	Pre-Gait Speed	−0.49	−6.55	< 0.001§	−0.64	−0.34		
Post-program Short FES-I*	Univariate Analyses							
	Age	−0.05	−2.23	0.026§	−0.09	−0.006	F(1, 283) = 6.06, p = 0.014§	0.02
	Sex	−0.01	−0.39	0.699	−0.08	0.53	F(1, 283) = 0.15, p = 0.699	--
	Post-BBS	−0.30	−5.62	<0.001§	−0.41	−0.20	F(1, 282) = 26.05, p < 0.001§	0.08
	Post-TUG	0.31	6.76	<0.001§	0.22	0.41	F(1, 282) = 39.00, p < 0.001§	0.08
	Post- 30 CST	−0.16	−3.63	<0.001§	−0.25	−0.08	F(1, 277) = 13.77, p = 0.003§	0.04
	Post-FR	−0.32	−4.32	<0.001§	−0.46	−0.17	F(1, 282) = 17.39, p < 0.001§	0.06
	Post-Gait Speed	−3.93	−4.99	<0.001§	−5.47	−2.38	F(1, 280) = 23.86, p < 0.001§	0.08

	Multivariate Analysis							
	Age	−0.007	−3.35	0.001[§]	−0.01	−0.004	F(4, 278) = 15.40, p < 0.001[§]	0.17
	Sex	0.001	−0.20	0.839	−0.06	0.06		
	Post-TUG	0.02	3.75	< 0.001[§]	0.01	0.03		
	Post-FR	−0.02	−2.81	0.005[§]	−0.03	−0.003		

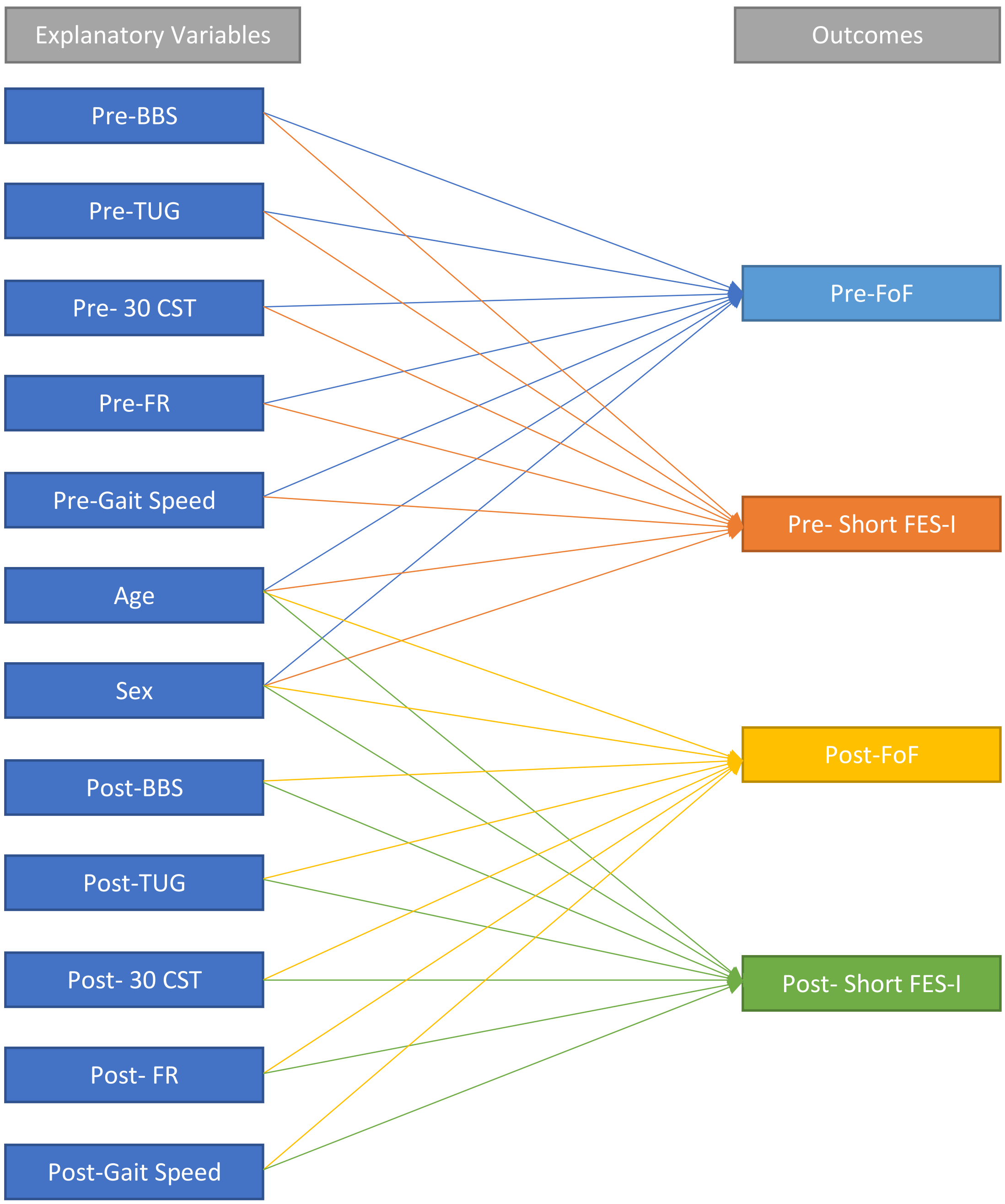
* logarithmic transformation

[§] Indicates significance at $p < 0.05$

-- indicates a robust regression

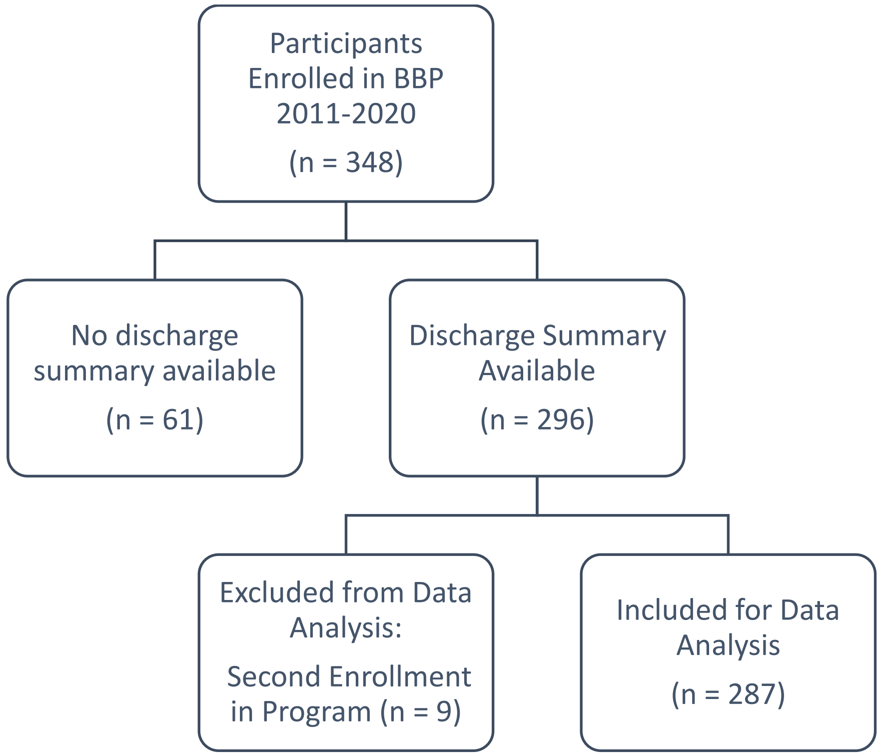
Var. = variable, Coef. = non-standardized coefficient, t = t-statistic, conf. interval = confidence interval, adj R^2 = adjusted R squared, pre-BBS = pre-program berg balance scale score, pre-TUG = pre-program timed-up and go time, pre- 30 CST = pre-program 30 seconds chair stand repetitions, pre-FR = pre-program functional reach distance, pre-gait speed = pre-program gait speed, post-BBS = post-program berg balance scale score, post-TUG = post-program timed-up and go time, pre- 30 CST = post-program 30 seconds chair stand repetitions, post-FR = post-program functional reach distance, post-gait speed = post-program gait speed

Figure 1. Visual Representation of the Linear Regression Models



Visual representation of the four distinct regression models with all explanatory variables tested

Figure 2. Participant Flow Diagram



Appendix I

TIDieR
Template for Intervention Description and Replication

The TIDieR (Template for Intervention Description and Replication) Checklist*: Information to include when describing an intervention and the location of the information

Item Number	Item	Where Located
1	**BRIEF NAME** Provide the name or a phrase that describes the intervention.	p. 111
2	**WHY** Describe any rationale, theory, or goal of the elements essential to the intervention.	p. 112
3	**WHAT** Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (e.g. online appendix, URL).	p. 112
4	Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities.	p. 112
5	**WHO PROVIDED** For each category of intervention provider (e.g. psychologist, nursing assistant), describe their expertise, background and any specific training given.	p. 112
6	**HOW** Describe the modes of delivery (e.g. face-to-face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group.	p. 112
7	**WHERE** Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features	p. 112
8	**WHEN and HOW MUCH** Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose	p. 112
9	**TAILORING** If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how	p. 112
10	**MODIFICATIONS** If the intervention was modified during the course of the study, describe the changes (what, why, when, and how).	p. 112
11	**HOW WELL**	N/A

	Planned: If intervention adherence or fidelity was assessed, describe how and by whom, and if any strategies were used to maintain or improve fidelity, describe them	
12	Actual: If intervention adherence or fidelity was assessed, describe the extent to which the intervention was delivered as planned	p. 112

** **Authors -** use N/A if an item is not applicable for the intervention being described. **Reviewers** – use '?' if information about the element is not reported/not sufficiently reported.

† If the information is not provided in the primary paper, give details of where this information is available. This may include locations such as a published protocol or other published papers (provide citation details) or a website (provide the URL).

ǂ If completing the TIDieR checklist for a protocol, these items are not relevant to the protocol and cannot be described until the study is complete.

* We strongly recommend using this checklist in conjunction with the TIDieR guide (see *BMJ* 2014;348:g1687) which contains an explanation and elaboration for each item.

* The focus of TIDieR is on reporting details of the intervention elements (and where relevant, comparison elements) of a study. Other elements and methodological features of studies are covered by other reporting statements and checklists and have not been duplicated as part of the TIDieR checklist. When a **randomised trial** is being reported, the TIDieR checklist should be used in conjunction with the CONSORT statement (see www.consort-statement.org) as an extension of **Item 5 of the CONSORT 2010 Statement.** When a **clinical trial protocol** is being reported, the TIDieR checklist should be used in conjunction with the SPIRIT statement as an extension of **Item 11 of the SPIRIT 2013 Statement** (see www.spirit-statement.org). For alternate study designs, TIDieR can be used in conjunction with the appropriate checklist for that study design (see www.equator-network.org).

Appendix II: TREND Statement Checklist

Paper Section	Item Number	Descriptor	Reported
Title and Abstract			
Title and Abstract	1	Information on how unit were allocated to interventions	N/A
		Structured abstract recommended	p.107
		Information on target population or study sample	p.107
Introduction			
Background	2	Scientific background and explanation of rational	p.109-110
		Theories used in designing behavioural intervention	N/A
Methods			
Participants	3	Eligibility criteria for participants, including criteria at different levels in recruitment/sampling plan (e.g., cities, clinics, subjects)	112
		Method of recruitment (e.g., referral, self-selection), including the sampling methods if a systematic sampling plan was implemented	112
		Recruitment setting	113
		Settings and locations where the data were collected	113
Interventions	4	Details of the interventions intended for each study condition and how and when they were actually administered, specifically including: • Content: what was given? • Delivery method: how was the content given? • Unit of delivery: how were the subjects grouped during delivery? • Deliverer: who delivered the intervention? • Setting: where was the intervention delivered? • Exposure quantity and duration: how many sessions or episodes or events were intended to be delivered? How long were they intended to last? • Time span: how long was it intended to take to deliver the intervention to each unit? • Activities to increase compliance or adherence (e.g., incentives)	112
Objectives	5	Specific objectives and hypotheses	110, 111
Outcomes	6	Clearly defined primary and secondary outcome measures	113–116
		Methods used to collect data and any methods used to enhance the quality of measurements	113
		Information on validated instruments such as psychometric and biometric properties	113–116
Sample Size	7	How sample size was determined and, where applicable, explanation of any interim analyses and stopping rules	N/A
Assignment Method	8	Unit of assignment (the unit being assigned to study condition, e.g., individual, group, community)	112
		Method used to assign units to study conditions, including details of any restriction (e.g., blocking, stratification, minimization)	N/A
		Inclusion of aspects employed to help minimize potential bias induced due to non-randomization (e.g., matching)	N/A
Blinding (masking)	9	Whether or not participants, those administering the intervention, and those assessing the outcomes were blinded to study condition assignment; if so, statement regarding how the blinding was accomplished and how it was assessed.	N/A
Unit of Analysis	10	Description of the smallest unit that is being analyzed to assess intervention effects (e.g., individual, group, or community)	116
		If the unit of analysis differs from the unit of assignment, the analytical method used to account for this (e.g., adjusting the standard error estimates by the design effect or using multilevel analysis)	N/A

Statistical Methods	11	Statistical methods used to compare study groups for primary methods outcome(s), including complex methods of correlated data	116
		Statistical methods used for additional analyses, such as a subgroup analyses and adjusted analysis	116
		Methods for imputing missing data, if used	N/A
		Statistical software of programs used	116
Results			
Participant Flow	12	Flow of participants through each stage of the study: enrollment, assignment, allocation, and intervention exposure, follow-up, analysis (a diagram is strongly recommended) • Enrollment: the numbers of participants screened for eligibility, found to be eligible, decline to be enrolled, and enrolled in the study • Assignment: the numbers of participants assigned to a study condition • Allocation and intervention exposure: the number of participants assigned to each study condition and the number of participants who received each intervention • Follow-up: the number of participants who completed the follow-up or did not complete the follow-up (i.e., los to follow-up), by study condition • Analysis: the number of participants included in or excluded from the main analysis, by study condition	141
		Description of protocol deviations from study as planned, along with reasons	N/A
Recruitment	12	Dates defining the periods of recruitment and follow-up	118
Baseline Data	14	Baseline demographic and clinical characteristics of participants in each study condition	133
		Baseline characteristics for each study condition relevant to specific disease prevention research	133
		Baseline comparisons of those lost to follow-up and those retained, overall and by study condition	N/A
		Comparison between study population at baseline and target population of interest	N/A
Baseline equivalence	15	Data on study group equivalence at baseline and statistical methods used to control for baseline differences	N/A
Numbers analyzed	16	Number of participants (denomitaor) included in each analysis for each study condition, particularly when the denominators change for difference outcomes; statement of the results in absolute numbers when feasible	116
		Indication of whether the analysis strategy was “intention to treat” or, if not, description of how non-compliers were treated in the analyses	N/A
Outcomes and estimation	17	For each primary and secondary outcomes, a summary of results for each estimation study condition, and the estimated effect size and a confidence interval to indicate the precision	118, 136-139
		Inclusion of null and negative findings	116
		Inclusion of results from testing pre-specified causal pathways through which the intervention was intended to operate, if any	N/A
Ancillary analyses	18	Summary of other analyses performed, including subgroup or restricted analyses, indicating which are pre-specified or exploratory	116
Adverse events	19	Summary of all important adverse events or unintended effects in each study condition (including summary measures, effect size estimates, and confidence intervals)	N/A
Discussion			
Interpretation	20	Interpretation of the results, taking into account study hypotheses, sources of potential bias, imprecision of measures, multiplicative analyses, and other limitations or weaknesses of the study	121

		Discussion of results taking into account the mechanism by which the intervention was intended to work (causal pathways) or alternative mechanisms or explanations	121, 124
		Discussion of the success of and barriers to implementing the intervention, fidelity of implementation	N/A
		Discussion of research, programmatic, or policy implications	124-126
Generalizability	21	Generalizability (external validity) of the trial findings, taking into account the study population, the characteristics of the intervention, length of follow-up, incentives, compliance rates, specific sites/settings involved in the study, and other contextual issues	121-124
Overall Evidence	22	General interpretation of the results in the context of current evidence and current theory	126

From: Des Jarlais, D. C., Lyles, C., Crepaz, N., & the Trend Group (2004). Improving the reporting quality of nonrandomized evaluations of behavioural and public health interventions: The TREND statement. *American Journal of Public Health*, 94, 361-366. For more information, visit: http://www.cdc.gov/trendstatement/

Appendix III

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	107
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	107
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	109
Objectives	3	State specific objectives, including any prespecified hypotheses	110-111
Methods			
Study design	4	Present key elements of study design early in the paper	111
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	112
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	112-113
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	113-116
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	113
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	116
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	116

		(*b*) Describe any methods used to examine subgroups and interactions	116
		(*c*) Explain how missing data were addressed	112
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	117
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	118
		(b) Give reasons for non-participation at each stage	118
		(c) Consider use of a flow diagram	141
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	118
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	118-121
		(*b*) Report category boundaries when continuous variables were categorized	116
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	121
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	125

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	125
Generalisability	21	Discuss the generalisability (external validity) of the study results	N/A
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

CHAPTER 5: DISCUSSION

5.1 Summary

The main objective of this thesis was to explore fall-related behavioural risk factors and their association with biological and environmental risk factors in community-dwelling older adults. Specifically, this thesis aimed to identify fall-related risk-taking behaviours, evaluate participants' physical function and fear of falling (FoF) following a community-based fall prevention program, and explore the relationship between FoF levels and physical function.

5.1.1 Risk-Taking Behaviours

The first study in this thesis was a scoping review which explored approaches used to identify fall-related risk-taking behaviours, common risk-taking behaviours, and factors associated with these behaviours. Chapters two and three are related to this study. Specifically, Chapter two presents the scoping review protocol, which highlights the conceptualization of fall-related risk-taking behaviours, while Chapter three presents the scoping review results.

Within the scoping review (Chapter three), Bran & Vaidis's (2020) typology of risk-taking guided the data extraction from thirty studies selected for inclusion. Bran & Vaidis (2020) have built on seminal risk-taking frameworks to provide an inclusive typology which includes the four core concepts of risk-taking: risk-taking behaviours, risk-taking propensity, risk-taking attitudes, and risk appraisal (Bran & Vaidis, 2020). Within each core concept of risk-taking various frameworks exist respective to the domain of risk-taking. For example, in financial risk, risk-taking behaviours are predicted by risk appraisal, which is influence by factors such as management team homogeneity (Sitkin & Pablo, 1992).

This scoping review identified self-reported measures gathered by qualitative methodologies were the most frequently reported approach used to identify fall-related risk-taking behaviours in community-dwelling older adults. Due to the heterogeneity of community-dwelling older adults, the scoping review could not identify a standard set of fall-related risk-taking behaviours. Rather, this scoping review provides a foundation for knowledge about fall-related risk-taking behaviours by describing the common approaches used to identify risk-taking behaviours and characterizing factors that influenced these behaviours. Generally, the scoping review identified older adults were aware of their own fall risk and described adopting protective behaviours to mitigate the risk of falling during activities of daily living. In some instances, older adults described deliberate acts of risk-taking behaviours, which were often influenced by the perceived potential benefits compared to risk associated with the behaviour.

This scoping review also demonstrates factors such as an individual's physical ability, the surrounding environment (social and physical) and the way an activity is performed (e.g., rushing vs. going slowly) can influence the individual's own perception of risk. An individual's perception, or appraisal of risk, in conjunction with their attitudes and tendencies to engage in risk, will impact the risk-taking behaviours they choose to engage in. Interestingly, this scoping review found a discrepancy between what behaviours researchers/family members and older adults considered risk-taking. For example, researchers often considered climbing objects, such as step ladders, as risk-taking, yet this was a routine behaviour and was not perceived by the older adult this as risky. It is possible that this discrepancy is due to the fact researchers perceived a higher risk associated with climbing an object than the older adults, who routinely engaged in this behaviour without experiencing a fall event. However, it remains unclear whether some behaviours are truly associated with a higher degree of risk or if these activities were characterized as risk-taking by researcher due to age-related stereotypes.

As risk-taking behaviours are individualized and situationally specific, the findings from this scoping review reinforce the need for clinicians to consider the relationship between an individual's physical ability, the social and physical environment, psychological implications, and the context of behaviours when considering and assessing the degree of risk associated with any behaviour. Clinicians should also approach recommendations of risk avoidance with caution, as this can lead an individual to experience negative self-perception and stigma related to ageing - both of which could lead to behaviour avoidance and further dependence (Coudin & Alexopoulos, 2010).

5.1.2 Fear of Falling

Chapter four of this thesis presents an analysis of 36 sequential cycles of a community-based, multi-component falls prevention program – the Building Balance Program (BBP) – which occurred between January 2011 to January 2020. The primary aim of this analysis was to evaluate if participants' physical function and level of fear of falling (FoF) improved following participation in the six-week fall prevention program. The secondary aim of this study was to assess the relationship between physical function and level of FoF in community-dwelling older adults who participated in the BBP. This analysis identified a ceiling effect with Berg Balance Scale (BBS) scores, suggesting that the BBS may not be an appropriate assessment tool for individuals with higher physical function who participated in this program. The Mini-BESTest is also a 14-item clinical tool that evaluates an individual’s dynamic balance control (Franchignoni et al., 2010). The Mini-BESTest may be a more appropriate test for community-dwelling older adults with better balance control, as it has demonstrated a better distribution of scores and appears to have a smaller ceiling effect compared to the BBS in community-dwelling older adults (Godi et al., 2013).

The analysis associated with this study also demonstrated individuals who completed the BBP had a statistically significant improvement in balance, lower extremity strength, postural stability, gait, and FoF. Although these improvements were significant, a number of participants were still considered to be at risk of falling after the intervention. For example, 37.6% of participants had a Timed-Up and Go (TUG) time above 11 seconds after completing the BBP. Lusardi et al., (2017) determined individuals with TUG times > 11 seconds had a 47% chance of falling in the next year, and those with TUG times < 12 seconds were at a 25% change of falling. As the BBP program was only six-weeks in duration, it is possible that it was not long enough for participants to reach levels of function that would permit scoring higher in both of these measures.

The regression analyses completed in this study identified a small association between physical function and level of FoF at baseline and post-program participation. For example, after controlling for sex, age and pre-program gait speed explained 18.0% of variations in log transformed pre-program short Falls Efficacy Scale – International (short FES-I) scores. This association was similar at the post-program participation, where age, TUG times, Functional Reach (FR) distances with a two-way interaction between FR distance and age explained 17.0% in log transformed post-program short FES-I scores. This means the level of FoF decreased alongside improvements in physical function. However, it is unclear why different measures of physical function explained variations in short FES-I scores at baseline and post-program.

Interestingly, the level of FoF at baseline and post-program was highest among the youngest participants, despite these participants having better performance on balance, muscle strength, and mobility tests. This finding might suggest FoF is not an age-specific construct, and future research on FoF should explore the concept of FoF in younger individuals (i.e., < 65 years). In addition, other factors such as psychological factors may partially mediate the relationship between FoF and physical function. As previous studies have demonstrated both psychological and physical factors associated with FoF (Pauelsen et al., 2018), clinicians should consider psychological factors when discussing FoF with clients presenting with balance and mobility issues.

5.2 Contributions to the literature

5.2.1 Risk-Taking Behaviours

This thesis has contributed to existing literature related to fall-related behavioural risk factors for older adults. To the knowledge of the author, this is the first time risk-taking behaviours for older adults in relation to falls has been systematically reviewed. Risk-taking is a broad construct that encompasses diverse concepts that have been studies across a range of domains (i.e., financial, health/safety, recreational, ethical, and social) (Weber et al., 2002) and throughout the lifespan. The scoping review completed for this thesis adopted a typology from the risk-taking field, to develop a foundation of knowledge for fall-related risk-taking behaviours. The scoping review identified factors such as an individual's physical ability, self-perception, the environment, and the context of the behaviours that may influence the risk appraisal. Future research on fall-related risk-taking behaviours could adapt determinant frameworks from other fields of study where risk-taking is well-established (e.g., finance/business management) and apply these frameworks to the context of fall-related risk-taking to build predictive models of risk-taking behaviours. A predictive model of risk-taking behaviours could help clinicians identify individuals who tend to engage in excessive risk-taking and provide potential targets for intervention. For example, if an individual tends to engage in risk-taking behaviours because their perception of their abilities exceeds their actual ability, a referral to an exercise program may be appropriate to decrease the gap between perceived and actual ability.

5.2.2 Fear of Falling and Community-based Fall Prevention

The BBP has established a partnership with local health care providers, including family health teams and local hospitals, to screen community-dwelling older adults who may be at risk of falling in North Simcoe County (Janecek et al., submitted). The screening and referral process for the BPP is similar to the Stopping Elderly Accidents, Deaths & Injuries (STEADI) algorithm proposed by the Center for Disease Control and Prevention (CDC; Stevens & Phelan, 2013). The CDC identifies community-dwelling older adults at risk of falling if they report feeling worried about falling, feeling unsteady when standing or walking, or have experienced a fall in the past year (Stevens & Phelan, 2013). Similarly, individuals who experience a FoF, have fallen in the past 12 months, or report a near fall experience in the last 3 months are screened at risk for falls and referred to the BBP (Janecek et al., submitted). As evidenced in this thesis, community-based exercise programs, like the BBP can be an excellent public health approach to reduce falls risk across populations. Individuals who participated in the BBP demonstrated significant improvements in physical function and decrease in FoF. Although some participants remained at an increased risk of falling after completing the BBP, a plan was developed for each participant based on their fall risk profile to ensure that participants had ongoing support following BBP completion. These plans included a discussion of a sustained home exercise program, referral to other fitness/wellness programs within the community, and/or in rare instances a referral to repeat the BBP again (Janecek et al., submitted). As there may be a psycho-social component involved with FoF, community falls prevention programs may also want to consider referrals to mental healthcare providers for individuals who remain fearful of falling post program completion.

The *fear-avoidance model of falling and functional disability* is a conceptual framework proposed by Peeters et al., (2020) and adapted from literature in chronic pain that considers learning mechanisms in movement-related fears to explain FoF. This framework highlights the potential relationship between cognitive, emotional, and physiological factors related to FoF (Peeters et al., 2020). As the fear-avoidance model of falling and functional disability has not been validated, further research using this framework is required to determine its validity. Future research should also consider including cluster analyses to identify common characteristics of subgroups of individuals to identify those with the highest risk of FoF and inform intervention selection. For example, cognitive behavioural therapy (CBT) has recently emerged as a potential intervention for FoF (Liu et al., 2018). However, a systematic review and meta-analysis demonstrated only a small effect size of 0.33 (95% CI 0.21-0.46) for CBT compared to control in community-dwelling older adults with FoF. As cognitive behavioural therapy is based on the cognitive model of mental illness and suggests that an individual’s emotions and behaviours are influenced by their perceptions, it is likely this intervention would only be effective in individuals who present with altered perceptions (Fenn & Byrne, 2013).

5.3 Limitations

There are some limitations to this thesis that should be acknowledged. As scoping reviews gather information from a wide range of methodologies, they cannot provide a causal relationship or determine cause and effect (Munn et al., 2018). Additionally, scoping reviews are not required to evaluate the quality of evidence formally or to complete a critical appraisal of the risk of bias (Peters et al., 2020). However, considering the review's objectives and the heterogeneity of the literature, a scoping review was the appropriate methodology (Munn et al., 2018) to explore an emerging area in the falls literature.

The analysis of existing clinical data from the BBP excluded cases that did not have at least one post-program outcome measure, and cases that corresponded to a participant’s second enrollment in the BBP. This led to the exclusion of seventy cases. In addition, as a one group pretest post-test design was utilized to evaluate whether participants’ physical function and fear of falling improved, the results may be biased. It cannot be certain that the change in physical performance and fear of falling was caused by the intervention and not by other unaccounted variables. Measurement bias may also exist as the physiotherapist who oversaw the management of the program conducted baseline and post-program assessments which could affect our results. As the BBP did not collect prospective on falls, our analysis was unable to determine to what extent this program reduced rate of falls and injurious falls. However, this analysis provides pragmatic representation of community-based fall prevention programs.

5.4 Conclusion

This thesis demonstrated fall-related behavioural risk factors are complex and are likely influenced by psychological factors (e.g., self-perception), physical function, and the social and physical environment. Risk-taking behaviours are an emerging area in falls literature. Self-reported behaviours gathered through qualitative methodology is the most common approached used to identify fall-related risk-taking behaviours. Risk-taking behaviours are likely influenced by factors such as an individual's abilities, personal values, self-perception, the physical and social environment, and the way an activity is performed.

Participation in a community-based, multicomponent (i.e., exercise and education) fall prevention program can reduce an individual's fall risk. As limitations in physical function are among the most critical risk factors for falling, and may influence behavioural risk factors, exercise-based fall prevention programs may be an appropriate first step in reducing falls risk. However, physical function may not be the only factor associated with FoF; others such as anxiety or depression could have an effect on FoF. As such, education sessions offered as part of community falls prevention programs may provide additional opportunities for older adults to learn about FoF and other modifiable risk factors for falls (e.g., home hazards), which may promote discussions with healthcare providers. However, these sessions should include referral opportunities for participants to discuss their unique situations when appropriate. For example, a referral to a psychotherapist may be beneficial for a participant presenting with excessive fear. Additionally, upon completing a fall prevention intervention, primary healthcare providers should follow up to re-assess the individual's fall risk profile and refer to additional interventions as appropriate.

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