Fear of falling after hip fracture: A systematic review of prevalence, measurement, associations with physical function, and interventions.

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HEAL997 Practice Project

A dissertation submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Masters of Health Practice (MHPrac)

2021

School of Clinical Sciences

Abstract

Background

Hip fracture is a common and debilitating injury amongst older adults. Fear of falling (FoF) may impede rehabilitation after hip fracture. An updated systematic review to synthesize the existing literature on FoF after hip fracture is needed.

Aim

This study aims to review and synthesize existing literature to answer four research questions about the 1.) prevalence of FoF, 2.) psychometric properties of measurement instruments, 3.) association with physical function, and 4.) effectiveness of interventions in reducing FoF, in hip fracture patients.

Methods

A systematic electronic search was undertaken in the EBSCO Health, Scopus and PsychINFO databases in January 2021 for articles on FoF after hip fracture. Data in relation to each research question was extracted and analysed. The methodological quality of the studies was critically appraised using the 'Risk of Bias Tool for Prevalence Studies', 'COSMIN Risk of Bias checklist for Patient-reported outcome measures', modified version of the 'Appraisal Tool for Cross-sectional studies', and the 'Cochrane Risk of Bias 2' tools for each research question, respectively.

Results

35 articles (34 studies) with 3809 participants were included. Prevalence rates for FoF after hip fracture ranged between 22.5% and 100%, and the prevalence tended to decrease as time progressed post hip fracture. The 'Falls Efficacy Scale – International' (FES-I) and 'Fear of Falling Questionnaire – Revised' (FFQ-R) were found to be reliable, internally consistent, and valid tools in hip fracture patients. FoF after hip fracture was consistently associated with measures of physical function including balance, gait speed, composite physical performance measures and self-reported function. Exercise-based interventions with or without a psychological component were not effective in reducing FoF after hip fracture. Motivational interviewing and accelerated/ supported

discharge with home based rehabilitation may have some impact on FoF, however, more high quality trials are needed to confirm this finding. Overall, the evidence is still insufficient to conclude about the effectiveness of interventions in reducing FoF after hip fracture.

Conclusion

The literature on FoF after hip fracture has grown in the last decade. FoF is prevalent after hip fracture and is associated with poorer physical function. Only two instruments have been validated for measuring FoF in the hip fracture population. However, there is a need for more robust and larger studies to guide clinical practice regarding interventions to address FoF after hip fracture.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed:

Chandini Gadhvi

October 2021

Acknowledgements

I would like to thank my supervisors Dr Debbie Bean and Dr David Rice who have been a great support in this project from beginning to end. They made themselves available to regularly discuss and plan each stage of the research and guided me with their pearls of wisdom. They continued to challenge me throughout the project to enable me to grow my learning.

I would like to thank my family – my parents for motivating me to pursue higher studies and constantly supporting me in every possible way so that I could spend more time on completing my project; my daughter for being patient and her warm smile expressing her understanding when she could see mum was a bit frazzled; my partner for his patience and finally my sister for her words of encouragement.

Abbreviations

ABC	Activities-specific Balance Confidence scale
BBS	Berg Balance Scale
CBT	Cognitive behavioural therapy
FES	Falls Efficacy Scale
FES-I	Falls Efficacy Scale International
FFQ-R	Fear of Falling Questionnaire Revised
FoF	Fear of falling
ICC	Intraclass correlation coefficient
IRR	Incidence rate ratio
MCID	Minimal clinically important difference
mFES	Modified Falls Efficacy Scale
MI	Motivational interviewing
MMSE	Mini-mental State Exam
OR	Odds ratio
PROMs	Patient-reported outcome measure(s)
RCT	Randomised controlled trial
SAFE	Survey of Activities and Fear of Falling in the Elderly
SDC	Smallest detectable change
SEM	Standard error of measurement
SIQ	Single item question
TUG	Timed up and go test
QoL	Quality of life

CHAPTER 1 INTRODUCTION

1.1 Hip fracture

Sustaining a fracture at the hip is a serious consequence of falls in older adults (ANZHFR, 2019). A hip fracture may involve a fracture above the hip joint capsule such as intracapsular, subcapital and neck of the femur fractures or below the joint capsule insertion (called extracapsular) e.g. inter-trochanteric, peri-trochanteric or subtrochanteric fractures. Hip fracture is managed surgically by operating on the fractured bone using options such as a total arthroplasty, hemiarthroplasty, and internal fixation, depending on characteristics of the fracture (NICE, 2011).

1.1.1 Epidemiology and burden

Hip fracture is one of the leading causes of disability among older adults worldwide and has become a major public health issue (Alexiou et al., 2018). As the population ages and life expectancy increases, fall-related hip fractures and subsequent admissions to hospital will also increase (ANZHFR, 2019). While there is varying data for different countries, hip fractures are estimated to affect 18% of women and 6% of men globally and it is expected that worldwide hip fracture numbers will increase to 4.5 million by 2050 (Veronese & Maggi, 2018). The Australian and New Zealand Hip Fracture Registry collects data on hip fractures and reports that over 25,000 people have a fall related hip fracture each year; this poses a cost of an estimated $1 billion annually (ANZHFR, 2019). The impact is huge for the individuals affected as well as the wider community with associated costs of acute treatment and rehabilitation, assistance with daily living activities and, in some cases, placement in long term care facilities (ANZHFR, 2019; Veronese & Maggi, 2018). Moreover, patients' physical and mental health and quality of life (QoL) are severely impacted post hip fracture (Alexiou et al., 2018).

1.1.2 Determinants of hip fracture

Age, osteoporosis and falls are considered to be the key determinants of hip fractures (Marks, 2010). While hip fractures can be multifactorial, the key risk factors for sustaining a hip fracture can be loosely categorised as those that decrease bone mineral density (e.g. older age, female gender, family history) and those that increase risk of falling (Veronese & Maggi, 2018). In addition, chronic health conditions such as Parkinson's Disease, cognitive impairment and visual impairment, as well as low level of participation in physical activity, certain medications and environmental factors may increase an individual's chance of falling and thus risk of sustaining a hip fracture (Marks, 2010, 2011). Therefore, hip fracture is considered a sign of frailty (Green et al., 2020).

1.1.3 Mortality and morbidity

Approximately 10% of patients die during acute hospitalisation following hip fracture. Factors associated with higher mortality during hospitalisation include advancing age, male gender and pre-existing comorbidities especially congestive heart failure and liver disease (Frost et al., 2011). Many studies report that mortality rates after hip fracture are relatively high, ranging between 10 – 20% at one year (Dyer et al., 2016; Haleem et al., 2008; Johansen et al., 2010; Kim et al., 2012). A recent systematic review reported the most up-to-date 1-year mortality rate as 22% (Downey et al., 2019). Recent research shows that the mortality rate post hip fracture is trending downward, however, it remains a significant cause for concern (Roberts et al., 2015). Additionally, hip fracture patients often have other co-morbidities which may impact on their rehabilitation and outcomes (Hindmarsh et al., 2014; Nikkel et al., 2012).

Cognitive impairment is an important factor that can influence hip fracture outcomes and recovery. Dementia and cognitive impairment are prevalent among hip fracture patients. A meta-analysis derived the estimated prevalence of dementia as 19.2% and that of cognitive impairment as 41.8% (Seitz et al., 2011). Cognitive impairment was a predictor of poorer functional outcomes for hip fracture patients (Kim et al., 2012). A systematic review concluded that cognitive impairment had a negative impact on health-related QoL after hip fracture, and the severity of cognitive impairment was correlated with deterioration in health-related QoL post discharge from hospital (Wantonoro et al., 2020). Likewise, dementia was associated with a substantially negative effect on outcomes after hip fracture (Karlsson et al., 2020).

Risk of further falls is another concern in hip fracture patients. Between 20% to 53% of hip fracture patients were reported to fall in the four to six months after their surgery (Kristensen, 2011). Also, one in 11 hip fracture patients sustained a second hip fracture in a large cohort study that followed-up participants until death (Harvey et al., 2018). A second hip fracture poses a risk for higher mortality and health burden and it is therefore important to put strategies in place for its prevention (Trevisan et al., 2020). Therefore, many patients may worry about further falls following hip fracture.

1.1.4 Rehabilitation and physical/ functional recovery

Rehabilitation following hip fracture aims to restore pre-fracture function as well as prevent disability (Corcoles-Jimenez et al., 2015). Many guidelines and systematic reviews strongly recommend early mobilisation (Beckmann et al., 2020; Chudyk et al., 2009; Reyes et al., 2020; Sherrington et al., 2011) and intensive physiotherapy (Chudyk et al., 2009; Roberts et al., 2015) to improve functional outcomes for hip fracture patients. Early mobilisation is associated with reduced complications post-surgery (ANZHFR, 2014). A randomised controlled trial (RCT) found that intensive physiotherapy (three times daily) during acute hospitalisation was safe, reduced length of stay and favoured better functional outcomes for hip fracture patients compared to usual physiotherapy (Kimmel et al., 2016). However, during the acute post-operative hospital stay, the level of physical activity among hip fracture patients was found to be very low (Davenport et al., 2015; Taylor et al., 2016). At 2 months post-fracture, most patients were found to engage in very limited physical activity (Resnick et al., 2011). A recent study found that hip fracture patients were sedentary for more than 10 hours in a 13 hour day (Zusman et al., 2019).

While it is clear that physical exercise is beneficial for hip fracture rehabilitation and functional recovery, the evidence around optimal dosage and prescription of exercise is still somewhat limited (Beckmann et al., 2020; Di Monaco, 2011; Handoll et al., 2011). The bulk of the functional recovery from a hip fracture occurs in the first four to six months, however, only a small proportion of patients recover their pre-fracture functional level (Bertram et al., 2011; Dyer et al., 2016). Most patients suffer a substantial reduction in physical function post-fracture (Sherrington et al., 2011). Recovery of walking or ambulation (both in and outdoors) is a significant functional outcome for these patients, however, recovery of this function can be poor (Salpakoski et al., 2014). A consensus of studies have shown that walking speed diminishes after hip fracture compared to that of healthy older adults (Chui et al., 2012).

Based on their review of several hip fracture studies, Dyer et al. (2016) report that only 40 –60% of patients regained their pre-fracture level of mobility and 40 – 70% regained their previous level of independence with basic activities of daily living. Between 20 – 60% of previously functionally independent adults needed assistance with tasks at 1 to 2 years post-fracture. Patients that were already living in residential care had poorer recovery of function than community-dwelling patients. Approximately 10 – 20 % of patients were institutionalised (moved into residential aged care) as an outcome of their hip fracture. Other studies (Bertram et al., 2011; Moerman et al., 2018; Osnes et al., 2004; Tang et al., 2016; Vochteloo et al., 2012) have also reported similar findings. In summary, despite widespread adoption of early mobilisation and exercise based rehabilitation, hip fracture survivors experience much worse mobility, function, health, QoL and institutionalisation than older adults without hip fracture, and many never recover their pre-fracture level of function (Dyer et al., 2016). Thus, a hip fracture has severe implications for physical function and it is imperative to understand the factors that can influence and optimise rehabilitation.

1.2 Fear of falling

Fear of falling (FoF) has been recognised as a health problem for older adults since the early 1980s (Legters, 2002). FoF is often a consequence of a fall (although it can also present in those who have not yet experienced a fall) and it can limit function beyond what may occur from the physical injury alone (Hadjistavropoulos et al., 2011; Tinetti et al., 1994). The prevalence of FoF in older adults can range between 21% to 85% depending on how it is measured and the characteristics of the population measured (Scheffer et al., 2008). Studies have also estimated FoF to be present in 12% to 65% of older adults who have not yet had a fall compared to 29% to 92% of those who have had a fall (Jorstad et al., 2005). Such a wide range of FoF prevalence is most likely due to a lack of consensus on its operationalisation as well as inconsistency in its measurement (Jung, 2008; Lavedan et al., 2018). Intuitively, FoF is likely to be even greater after hip fracture (Crotty et al., 2010; Kristensen, 2011). A recent longitudinal study reported that the prevalence of FoF was high, affecting 60.5% of participants at four weeks and 47% at twelve weeks after hip fracture (Bower et al., 2016). However, no recent systematic reviews have been conducted with a focus on identifying the prevalence of FoF after hip fracture.

FoF is considered to be a multifactorial phenomenon (Pena et al., 2019), as multiple factors appear to contribute to it (Jung, 2008; Legters, 2002). A plethora of studies have investigated the risk factors for FoF. The four most commonly reported risk factors are increased age, female gender, history of falls, and physical or functional impairment (Belloni et al., 2020; Curcio et al., 2020; da Cruz et al., 2017; Jung, 2008; Oh et al., 2017). The literature consistently reports that women are more likely to have FoF (Austin et al., 2007; Curcio et al., 2020; Merchant et al., 2020; Oh et al., 2017). Other risk factors for FoF that have been identified include, poor self-rated health (Jung, 2008; Oh et al., 2017; Scheffer et al., 2008), depression (Hughes et al., 2015; Merchant et al., 2020; Rivasi et al., 2020; Scheffer et al., 2008), co-morbidities (Jung, 2008; J. Lee et al., 2017; Oh et al., 2017), and cognitive impairment (Ivanovic & Trgovcevic, 2018; Scheffer et al., 2008).

1.2.1 FoF and related constructs: definitions, theory and terminology

FoF is defined as "a lasting concern about falling that leads to an individual avoiding activities that he/ she remains capable of performing" (Tinetti & Powell, 1993, p. 36). The construct of FoF is often operationalised by two similar and closely related constructs, namely 'falls efficacy' and 'balance confidence' (Jorstad et al., 2005; Moore & Ellis, 2008; Schepens et al., 2012). Evidently, the terms of FoF, falls efficacy and balance confidence have been used interchangeably in the literature (Li et al., 2002; Moore & Ellis, 2008) and the term FoF is commonly used as an umbrella term to encompass these constructs (Denkinger et al., 2015).

In 1990, Tinetti et al. and colleagues conceptualised FoF as "low perceived self-efficacy at avoiding falls during essential, non-hazardous activities of daily living" (p. 239). In the context of FoF, self-efficacy is one's beliefs and confidence about their ability to avoid a fall, also called falls efficacy (Hadjistavropoulos et al., 2011). This conceptualisation is based on Bandura's social cognitive theory (Hadjistavropoulos et al., 2011; Tinetti et al., 1990) which proposes that an individual's perceived self-efficacy influences their activity performance (Schepens et al., 2012). Falls efficacy (fall-related self-efficacy) was introduced as a measure of FoF when Tinetti et al. (1990) developed the Falls Efficacy Scale (FES) instrument. The authors (Tinetti et al., 1990; Tinetti & Powell, 1993) listed a number of advantages of defining FoF as low falls efficacy but the main benefit was that it enabled a window into function because FoF and falls efficacy may be a remediable contributor to functional decline. However, the thinking and understanding about these constructs has evolved over the past three decades (Soh, Tan, et al., 2021) and is still contentious. Some authors argue that falls efficacy should be considered to be a related but distinct construct (Hadjistavropoulos et al., 2011; Hughes et al., 2015; Li et al., 2002; Soh, Tan, et al., 2021) that measures perceived falls risk and psychological sequalae of falls (Schepens et al., 2012) rather than FoF per se. In other words, falls efficacy measures may not capture the emotional aspect of fear (Hadjistavropoulos et al., 2011; Soh, Tan, et al., 2021).

Balance confidence is a related construct which was reported by Powell and Myers (1995) when they developed the Activities-specific Balance Confidence (ABC) scale. This scale was designed to include activities of greater difficulty to suit older adults with higher performance, but was still designed to measure FoF utilising the same falls efficacy construct used by Tinetti et al. (1990) for the FES instrument (Jung, 2008). Balance confidence refers to an individual's confidence in their ability to maintain balance or remain steady and is effectively a form of self-efficacy relating to an individuals perceived ability to maintain balance in certain situations or tasks (Moore & Ellis, 2008). In fact, balance confidence has been considered to be equivalent and interchangeable to falls efficacy; the ABC and FES are very similar, are highly correlated, and it has been suggested that measuring both may be tautological (Hadjistavropoulos et al., 2011; Hatch et al., 2003; Hotchkiss et al., 2004; Soh, Lane, et al., 2021).

1.2.2 Measurement

FoF is measured using self-report questionnaires about whether or how afraid a person is of falling. Falls efficacy and balance confidence questionnaires measure the person's level of concern about falling, or confidence in maintaining balance, while doing activities of daily living (Jorstad et al., 2005; Peeters et al., 2020). Falls efficacy and balance confidence are considered measures of FoF even though it has been argued that they are closely related but distinct variables, and, as discussed above, many researchers have used these constructs interchangeably because of their similarity in nature (Hadjistavropoulos et al., 2011; Hughes et al., 2015; Li et al., 2002; Moore & Ellis, 2008). Therefore, for the purpose of this systematic review, FoF will be used as an umbrella term that includes falls efficacy and balance confidence.

A brief description and key features of the commonly used FoF measures is presented in Table 1. As shown in the table, there are several instruments available; thus there is a challenge in determining a ‘gold standard’ or ‘criterion’ measure (Moore & Ellis, 2008). The psychometric properties of some of these instruments have been investigated (see Table 1), however, some still need further research (Jorstad et al., 2005; Moore & Ellis, 2008). The FES is used most widely and has numerous modified or adapted versions including the Falls Efficacy Scale – International or FES-I (Moore & Ellis, 2008).

FoF may be particularly relevant to measure after hip fracture. Sustaining a serious injury such as a hip fracture can be a traumatic event, therefore, FoF could manifest differently after hip fracture compared to that in older adults who have not sustained a fall or a serious fracture. FoF may be more intense in these patients particularly early after the fracture, which could create ceiling effects in scales. Moreover, there may be some important differences in measuring FoF in the post-fracture rehabilitation context (compared to a community setting). It is therefore worth investigating whether or not the above FoF measurement instruments are psychometrically appropriate for use specifically in hip fracture patients. This will help establish whether these instruments are reliable and valid to use after hip fracture, particularly during rehabilitation. Recently, some studies have specifically investigated the psychometric properties of instruments, including the FES-I, in hip fracture patients (Bower et al., 2015; Visschedijk et al., 2015). These findings need to be collated in a systematic review.

Table 1

Instruments used to measure FoF and related constructs

Instrument	Description, key features and psychometric properties
CONSTRUCT: FALLS EFFICACY	
Falls Efficacy Scale (FES)	Developed by Tinetti et al. (1990). A 10 item questionnaire asking respondents to rate their level of confidence in performing common activities like 'getting dressed' or 'taking a shower or bath' – but all indoor activities; each item scored on a 10 point scale (Hatch et al., 2003; Jung, 2008). Found to have good reliability and validity (Tinetti et al., 1990). However, does appear to have a ceiling effect (Huang & Wang, 2009).
Modified Falls Efficacy Scale (mFES)	Upgraded version of the FES – added four questions about outdoor activities so can be used with community-dwelling older adults; found to be highly reliable and valid (Hill et al., 1996).
Falls Efficacy Scale-International (FES-I)	Developed by Yardley et al. (2005) to address some of the sensitivity issues of the FES as well as to make the scale more suitable for a wide range of cultural contexts. 16 item questionnaire measuring 'level of concern' of falling while carrying out certain activities, scored on a four point scale from 1 (not concerned at all) to 4 (very concerned). Found to have excellent test-retest and internal reliability and also slightly better discriminative power than the original FES (Yardley et al., 2005). Also found to be valid, reliable and comparable cross-culturally in a systematic review (Marques-Vieira et al., 2016).
Short Falls Efficacy Scale - International (sFES-I)	A shortened 7-item version of the FES-I questionnaire developed by Kempen et al. (2008) to make the instrument more practical for clinical use. Found to be correlated with the FES-I and excellent reliability (Kempen et al., 2008).
Perceived Ability to Manage Falls and Falling Scale (PAMF)	Developed by (Lawrence et al., 1998), this scale measures the participant's beliefs about managing falls in relation to both avoiding falls and handling a fall if experienced. It consists of 5 items with a 4-point response scale for each (scores range from 5 to 20). It has acceptable internal consistency.
CONSTRUCT: BALANCE CONFIDENCE	
Activities-Specific Balance Confidence Scale (ABC)	Developed by Powell and Myers (1995), a 16 item questionnaire asking respondents to score their level of confidence in performing specific activities such as 'picking slipper from floor' or 'walking in crowded mall', without losing their balance or becoming unsteady. Each item scored between 0% confidence to 100% confidence (Hatch et al., 2003; Jung, 2008). Found to have good test-retest reliability and internal consistency in community-dwelling older adults (Cleary & Skornyakov, 2014) However, does appear to have a ceiling effect (Huang & Wang, 2009).

CONSTRUCT: FEAR OF FALLING	
Single item question (SIQ) e.g. “Are you afraid of falling?”	A number of studies have referred to a SIQ enquiring about the presence of fear of falling with a simple ‘yes’ or ‘no’ answer (Jung, 2008; Legters, 2002). Studies have used questions with different wordings as there is no standardised version. While a SIQ may be straightforward to use (Jung, 2008), its use has mostly been criticised. A SIQ cannot measure the degree of fear present (unless a Likert scale response is used) and may not predict actual behaviour and thus has limited clinical use (Tinetti et al., 1990); it is not able to identify the most feared activity with which to target interventions (Belloni et al., 2020; Greenberg, 2012). Also, there is limited evidence about the psychometric properties of SIQ for FoF (Jorstad et al., 2005).
Survey of Activities and Fear of Falling in the Elderly (SAFE)	Developed by Lachman et al. (1998), this instrument measures FoF and activity restriction in relation to 11 activities such as ‘taking a shower’ or ‘taking public transportation’. A number of questions are asked for each activity including ‘Do you currently do it?’, ‘…when you do it, how worried are you that you might fall? (Jung, 2008; Lachman et al., 1998). Found to have good or adequate validity and reliability (Lachman et al., 1998).
Visual Analogue Scale for Fear of Falling (VAS-FOF)	A numeric 10 point scale measuring perceived FoF after a fall where 1 = no FoF and 10 = extreme FoF. It had fair test-retest reliability and moderate concurrent validity (Scheffer et al., 2010).
Fear of Falling Questionnaire (FFQ)	A 20 item questionnaire (with 4-point scale responses) designed based on the cognitive appraisal model of emotion by Lazarus to measure fear which is considered to be an emotion. This instrument is not as widely known or used as some other instruments (Greenberg, 2012) but it did demonstrate good reliability and validity for community-dwelling older adults (Dayhoff et al., 1994). Bower et al. (2015) have studied a revised version of this instrument (FFQ-R) specifically in hip fracture patients; both 15-item and 6-item versions of the FFQ-R were found to have good test-retest reliability and adequate construct validity.
Geriatric Fear of Falling Measure (GFFM)	Designed for older adults, consists of 15 items to assess FoF through three subscales (psychosomatic symptoms, adopting an attitude of risk prevention and modifying behaviour), designed to be completed by healthcare providers. It has good internal consistency, reliability and validity (Huang, 2006).

1.2.3 Potential consequences and impact of FoF

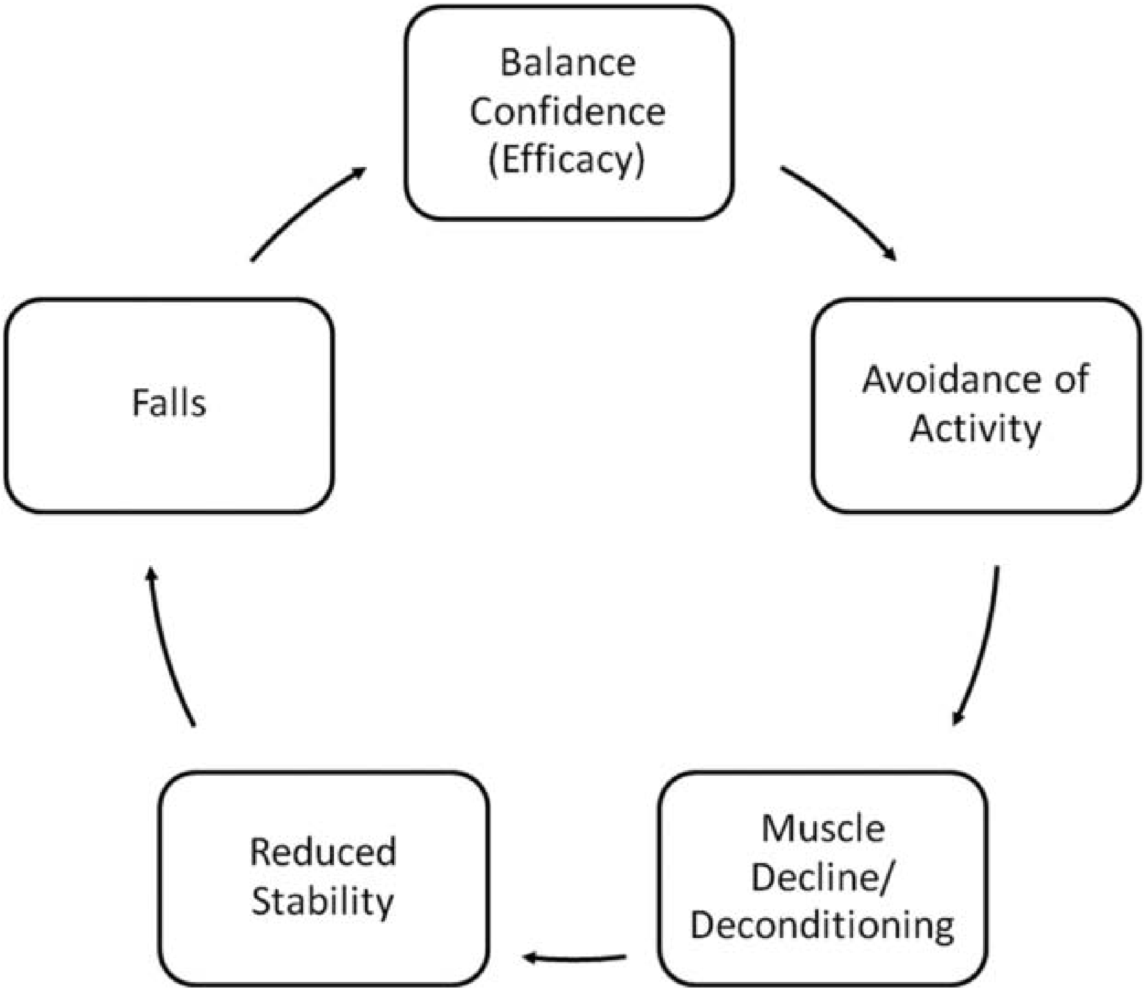
FoF may impact a number of variables including physical function and risk of subsequent falls (Perez-Jara et al., 2010; Scheffer et al., 2008). The 'fear avoidance' model (Figure 1) is a good theoretical framework to understand the concept of FoF and how it may influence physical function and falls (Peeters et al., 2020). Older adults tend to avoid activities as a result of their FoF (Hadjistavropoulos et al., 2011). This fear related avoidance of activity could be a reasonable and cautious response and may aid fall prevention (as individuals are more careful with the activities they chose to participate in), however, when fear related avoidance is excessive, such that it affects the individual's mobility, it can become debilitating (Deshpande et al., 2008; Evitt & Quigley, 2004; Jung, 2008; Moore & Ellis, 2008). This can lead to a vicious cycle of decreased independence and frailty, wherein, FoF leads to excessive activity restriction, which in turn leads to muscle atrophy and physical deconditioning, which leads to impaired balance and gait, and consequently, increases the risk of further falls (Hadjistavropoulos et al., 2011).

The link between FoF and activity restriction has been explored extensively in the literature. Numerous studies have reported activity restriction in older adults with FoF (Denkinger et al., 2015; Deshpande et al., 2008; Dias et al., 2011; Fletcher et al., 2010). Evitt and Quigley (2004) summarise that 13 – 35% of community-dwelling older adults avoid activities as a result of their FoF. Likewise, hip fracture patients are also reported to avoid activities as a result of their FoF (Jellesmark et al., 2012; Proctor et al., 2008). Older adults with FoF who restricted activities demonstrated lower falls related self-efficacy, higher depressive symptoms, lower gait velocity, lower independence in activities of daily living, and poorer self-perception of health (Dias et al., 2011).

FoF has also been identified as a risk factor for falling in older adults (Lavedan et al., 2018; Pena et al., 2019). A recent meta-analysis reported a 12.15 times greater chance of falling in older adults with FoF than those without (Pena et al., 2019). FoF was significantly associated with incidence of falls in hospitalised older adults (Dadgari et al., 2020) and higher levels of FoF among patients recently discharged, was linked to an increased risk of falling 3 to 6 months later (Lanoue et al., 2020).

Figure 1

Fear avoidance cycle – conceptualisation of FoF



Note.“Balance Confidence (Efficacy)” is a measure of FoF. Taken from “Reconceptualizing the role of fear of falling and balance confidence in fall risk”, by Hadjistavropoulos et al. (2011), *Journal of Aging and Health*, *23*(1), p 10.

FoF is frequently associated with poorer physical function, as reported by several studies. Elderly people with FoF scored worse in physical function measures like the Timed Up and Go (TUG) test and Short Physical Performance Battery compared to elderly people without FoF (Park et al., 2014) and FoF was associated with reduced gait performance and increased gait variability (Rochat et al., 2010). FoF was found to have a greater association with physical dependence than the actual falls and related injuries sustained (Pereira et al., 2020). Reduction in social participation, depression and reduced QoL are some other potential consequences of FoF in older adults (Bjerk et al., 2018; Scheffer et al., 2008; Schoene et al., 2019). Consequently, the impact for those with FoF can be huge and far-reaching because of the associated activity restriction, reduced mobility/ function, risk of further falling as well as barrier to engagement in therapy (Adamczewska & Nyman, 2018; Hatch et al., 2003; Schepens et al., 2012).

In hip fracture patients, FoF has been similarly linked to physical function in a number of studies. Lower falls efficacy or balance confidence was associated with poorer physical or functional performance measures in these patients (Eckert et al., 2020; Edgren et al., 2013). High FoF predicted poorer functional recovery, especially in older adults with better physical function pre-fracture (Bower et al., 2016). At six weeks post hip fracture, FoF was a stronger predictor of gait speed and balance performance than pain and depression (Oude Voshaar et al., 2006). As such, FoF may be an influential factor in functional recovery after hip fracture and is a potentially modifiable factor worth addressing to enhance rehabilitation outcomes (Bower et al., 2016; Petrella et al., 2000). However, there have been no recent systematic reviews that attempt to collate these relationships, with a view to informing future clinical practice.

1.2.4 Interventions to address FoF

Given the growing understanding of FoF as a multi-factorial issue, both physical and psychological interventions may be needed (Bula et al., 2011; Ganji, 2018; Parry et al., 2013). A number of studies have investigated potential interventions for reducing FoF among community-dwelling older adults (not hip fracture patients). A recent review (Whipple et al., 2018) included 44 studies and found that exercise (such as strength, agility, balance) and tai chi as well as multi-component interventions that included a cognitive behavioural therapy (CBT) component were effective. A systematic review (Zijlstra et al., 2007) of 19 clinical trials found that a number of interventions were effective which included fall-related multifactorial interventions, tai chi and home based exercise. Exercise has the potential to reduce FoF by improving strength, balance, gait and recurrence of falls as well as mood (Kendrick et al., 2014). Additionally, reducing the impact of a fall by using products like hip protectors or specialised flooring may also be beneficial (Evitt & Quigley, 2004).

In hip fracture patients, clinical trials have investigated a range of interventions for FoF. For instance, Scheffers-Barnhoorn et al. (2019) have investigated the effects of a multi-component 'FIT-HIP' intervention on FoF after hip fracture. A RCT investigated the effects of a 'Step-by-Step' programme incorporating CBT on FoF (Pfeiffer et al., 2020) while another (Van Ooijen et al., 2016) investigated the effects of a treadmill training programme on reducing FoF in hip fracture patients. A number of other such trials have been published in the last decade, however, their findings may be disparate and inconsistent and there are currently no clear recommendations for clinicians to guide their practice. Previous systematic reviews (Chudyk et al., 2009; Handoll et al., 2011; K. Lee et al., 2020) have reviewed effects of interventions during hip fracture rehabilitation but none have focussed on FoF specifically. Therefore, there is a strong need for a systematic review to synthesize and collate the findings of FoF intervention trials to draw recommendations for practice.

1.3 Statement of the problem

FoF appears to be an issue that can influence hip fracture rehabilitation, and addressing it may improve outcomes for patients (Kristensen, 2011). Consolidating our knowledge and understanding of the prevalence and measurement of FoF after hip fracture, how it interacts with variables of physical and functional performance as well as how best to address FoF in hip fracture rehabilitation is therefore necessary.

To date, there has only been one systematic review on FoF in hip fracture patients, in 2010 (Visschedijk et al., 2010). This review identified a number of areas in the field of 'FoF after hip fracture' that needed further research. Firstly, there were no studies that consistently measured FoF prevalence in hip fracture patients. Secondly, most studies included otherwise healthy patients and further research that included hip fracture patients with cognitive impairment or other co-morbidities was suggested. Additionally, further trials focusing on intervention programs was needed and these trials needed to be better powered and with longer follow-up. Another gap identified was a need for studies to establish the relationship between FoF and important outcomes such as physical function after hip fracture. While this review reported on the association of FoF with a wide range of variables, a more updated focus on association with measures of physical performance would be valuable. Finally, the systematic review by Visschedijk et al. (2010) revealed that no study had yet investigated the psychometric properties of instruments used to measure FoF, in hip fracture patients.

A Cochrane review was also published in 2010 that looked at rehabilitation interventions for physical and psychological functioning (including FoF) after hip fracture (Crotty et al., 2010). This review concluded that psychological outcomes post hip fracture may be amenable to interventions, but the evidence base was too limited at that point in time to make specific recommendations and the review concluded that further research was needed.

Over the past decade, a number of new studies focusing on FoF after hip fracture have been published, many of which help address some of these gaps. For example, some studies have investigated the psychometric properties of FoF measures (Bower et al., 2015; Visschedijk et al., 2015). Several cross-sectional and observational studies have investigated FoF prevalence, as well as associations between FoF and measures of physical function (Bower et al., 2016; Portegijs et al., 2012). Finally, several recent RCTs have investigated the effects of interventions on FoF during the course of hip fracture recovery (Pfeiffer et al., 2020; Scheffers-Barnhoorn et al., 2019; Van Ooijen et al., 2016). This emerging evidence could contribute to more effective management of hip fracture patients in their journey from surgery through to recovery and transition back into the community.

Thus, there is now a need for an updated systematic review to gather and collate the current evidence and provide up-to-date recommendations for clinical practice. Therefore, this systematic review will review current literature with a view to answer four research questions, as follows:

1. What is the prevalence of FoF in patients after hip fracture?
2. What are the psychometric properties of the instruments used to measure FoF in the hip fracture patient population?
3. What is the association between FoF and measures of physical function or performance after hip fracture?
4. Which interventions are effective in reducing FoF after hip fracture?

For research question 3, ‘physical function’ was chosen as a focus because it has been consistently associated with all constructs of FoF in older adults (Denkinger et al., 2015) and because of its clinical relevance to hip fracture rehabilitation.

1.4 Significance of research

This systematic review will provide an up-to-date synthesis of relevant literature in the field of FoF after hip fracture. It will be of significance to health professionals as well as caregivers involved in hip fracture care and rehabilitation. In particular, it will help to determine the significance and impact of FoF on hip fracture sufferers. Additionally, it will guide health professionals in the appropriate measurement of FoF after hip fracture. The findings may also provide clinicians with information about interventions to address FoF and help inform their practice. In addition to providing implications for practice, this systematic review will help identify gaps in current literature and in turn guide future directions for research in this topic area.

CHAPTER 2 METHODOLOGY

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (Moher et al., 2009). A protocol for this review was developed and registered on PROSPERO (CRD:42020221836).

2.1 Search strategy

A systematic search was performed in January 2021 in the electronic databases of EBSCO Health Databases (including CINAHL Complete, MEDLINE and SPORTDiscus), Scopus, and PsychINFO for studies on FoF after hip fracture. The keywords “hip”, “proximal femur”, “neck of femur”, “nof”, “inter-trochanter”, “intertrochanter”, “inter trochanter”, “sub-trochanter”, “subtrochanter” or “sub trochanter” within proximity to the term “fracture” were used to capture the patient population of interest. The search terms of “fear”, “self-efficacy”, “self efficacy”, “confidence”, “falls efficacy” or “falls-efficacy” within proximity to the terms “fall”, “falls”, “falling” or “balance” were used to search for our topic of interest. The appropriate proximity search, truncations and Booleans were utilised depending on each database. A detailed search strategy for each database is outlined in Appendix A.

2.2 Inclusion and exclusion criteria

Identified studies were included if they: (1) included participants with a diagnosis of hip fracture, (2) measured FoF, (3) had full-text available in English, and (4) answered one of the four research questions. Studies were excluded if they were: (1) not peer-reviewed, (2) not original research, (3) performed in a mixed population where independent data on hip fracture participants could not be extracted or obtained, (4) qualitative studies, (5) uncontrolled trials, (6) pilot or feasibility studies, and (7) studies that did not report their FoF data. The exclusion of pilot and feasibility studies (for research question 4) was added to the criteria after submission of the protocol on Prospero, but was deemed appropriate for this systematic review.

2.3 Study selection

The search strategy was applied to all databases by two members (CG, DB) of the research team simultaneously. All identified studies were downloaded and duplicates were removed manually. The titles and abstracts were screened by two reviewers (CG and DB) independently according to the inclusion and exclusion criteria. The full-texts of all potentially eligible studies were screened. Disagreements on article inclusion/ exclusion were discussed by the two reviewers and a third person (DR) was involved if an agreement could not be reached. The reference lists and forward citations (using Google Scholar and Scopus) of all included studies were searched to look for further relevant studies.

2.4 Data extraction

Two reviewers independently extracted data from all included studies into a Microsoft Excel spreadsheet (CG and DB, questions 2 and 3; CG and DR, questions 1 and 4). The two reviewers discussed any disagreements and a third person (DB or DR) was involved if required. For each included study the following data were extracted: study design and details, sample size, participant characteristics (age, gender), days since hip fracture and FoF measure(s) used. Additionally, for research question 1, FoF prevalence; for research question 2, statistical data pertaining to internal consistency, reliability, validity and other related psychometric properties of outcome measures; for research question 3, outcome measure used for the comparator variable (physical functional or performance factors) and correlation or regression statistics measuring the association between the comparator variable and FoF; and for research question 4, intervention used and resulting FoF data comparing the intervention group with control group as well as drop-out rate, were extracted where applicable. One RCT had included mostly hip and some pelvic fracture patients (Pfeiffer et al., 2020); this author was contacted and data specific to only the hip fracture participants included in their study were obtained.

2.5 Quality and risk of bias appraisal

Each included study was appraised by two reviewers; CG and DB reviewed the quality of the studies for research questions 2 and 3 while CG and DR appraised the studies for research questions 1 and 4. Any disagreements were resolved by involving the third reviewer. The four research questions were answered by studies of different designs; therefore, four quality assessment tools were required to appraise the included studies (one tool for each research question).

Prevalence studies included to answer the first research question were appraised using the Risk of Bias Tool for Prevalence Studies (Hoy et al., 2012) which is a 10 item tool assessing external and internal validity of the study across four domains of bias (namely selection bias, non-response bias, measurement bias and bias related to analysis). Additionally, there is a summary assessment where the rater makes an evaluation of the overall risk of bias based on the findings from the 10 items. This tool was found to have high inter-rater agreement and is easy to use (Hoy et al., 2012).

Studies investigating psychometric properties of outcome measures were appraised using the COSMIN Risk of Bias checklist for Patient-reported outcome measures (PROMs) instruments (Mokkink et al., 2018). This is a comprehensive tool designed specifically for use by systematic reviews of PROMs so that the methodological quality of the included studies as well as the measurement properties of the PROMs can be assessed. The tool has 10 sections addressing the following areas: PROM development, content validity, structural validity, internal consistency, cross-cultural validity/ measurement invariance, reliability, measurement error, criterion validity, hypotheses testing for construct validity and responsiveness. Of these, only the relevant sections were completed for each included study based on the psychometric testing undertaken by the study.

A modified version of the Appraisal Tool for Cross-sectional studies (AXIS) tool (see Appendix B) was used to appraise the cross-sectional and prospective longitudinal studies that were included to answer the third research question. The original version of the AXIS tool (Downes et al., 2016) consisted of 20 questions covering many potential areas of bias including sampling, selection, non-response, and measurement bias but was missing some important areas of potential bias including ‘adjustment for confounding variables’ and ‘assessor blinding’. In addition, because prospective longitudinal studies were included, an item on ‘loss to follow-up’ was necessary. After discussion and deliberation, three further questions based on the NIH tool for cross-sectional and cohort studies (NIH, 2021) were added to the AXIS tool to incorporate important areas of bias risk. Hence, the final tool consisted of 23 questions.

Finally, clinical trials answering research question 4 were evaluated using the Cochrane Risk of Bias 2 tool, known as RoB2 (Sterne et al., 2019), which is an updated version of the Cochrane risk-of-bias tool. This tool contains 5 domains for assessing bias in randomised trials which are: 1. risk of bias from the randomisation process, 2. risk of bias due to deviations from the intended interventions, 3. missing outcome data, 4. risk of bias in measurement of the outcome, and 5. risk of bias in selection of the reported result. The tool provides algorithms which can be used to make a judgement about the risk-of-bias in each domain from which an overall risk-of-bias judgment is determined for each study.

2.6 Data analysis

The data were analysed and synthesized for each of the four research questions separately. For research question 1, the extracted prevalence rates were analysed in relation to the time point at which they were measured. The data was graphed on a scatter plot with prevalence rate plotted against the time (in weeks) at which it was measured. When the prevalence rate was given for a time period, the mid-point of that time period was used to plot the prevalence rate; for example, for a period of 2 – 6 months, the 4 month mark was used. The range of prevalence rates for the following time periods post-fracture are also described in the text: 1-4 weeks, ~12 weeks and 12-58 weeks.

For research question 2, the data for each instrument were individually extracted and tabulated. The statistical values for each psychometric property were interpreted as follows. For test-retest reliability, the extracted intraclass correlation coefficient (ICC) values were analysed as poor, moderate, good or excellent based on accepted rules of thumb (Koo & Li, 2016). Cronbach's alpha coefficients for internal consistency were classed between 'unacceptable' to 'excellent' based on accepted rules of thumb (George & Mallery, 2003). Construct validity was described based on confirmation of 'a priori' hypotheses and strength of correlations with related constructs. Results from factor analysis were used to describe structural validity. Measurement error was interpreted as reported in the individual study.

Data extracted for studies in relation to question 3 were categorised based on the physical function or performance measure that FoF was associated with, which were: balance, gait speed, composite physical performance measure (e.g. Performance Oriented Mobility Assessment, TUG test), self-reported function, physical activity (e.g. step count), and muscle strength. For each category, the extracted statistical data was tabulated. Most studies performed Pearson or Spearman's correlations to measure the association between FoF and the chosen physical function measure (reported as the correlation coefficient 'r'). The strength or magnitude for each correlation coefficient was determined using Cohen's guide as follows: 0.10 – 0.29 is small, 0.30 – 0.49 is medium and $\geq$ 0.50 is large (Cohen, 1988). Some studies performed logistic regression analyses revealing an odds ratio (OR) for a dichotomous outcome; these were converted into an effect size (Cohen's D or standardised mean difference) using the formula: 'ln (OR) / 1.81' (Chinn, 2000). Where the OR was less than 1, it was first converted into a number greater than 1 by using 1/OR to result in a positive number. The resulting effect size was interpreted using Cohen's guide wherein 0.20 to 0.49 is considered a small effect size, 0.50 to 0.79 is medium and 0.80 and above is a large effect size (Cohen, 1988). A value below 0.20 was considered negligible. Some studies reported unstandardized or standardized beta coefficients from regression analyses. These were interpreted by taking the r^2 to determine how much variance in the comparator variable was explained by the FoF variable (Hoyt et al., 2006) or by imputation of an r value from the standardised beta coefficient (Peterson & Brown, 2005). Only one study performed a negative binomial or Poisson regression (Edgren et al., 2013) and reported an incidence rate ratio (IRR) which was analysed as reported by the study. Then for each of the categories of physical function, the strength of the associations with FoF were summarised.

In order to analyse the effectiveness of interventions (for research question 4), an effect size was calculated where possible. Where means and standard deviations (SD) for the intervention group and control group were provided, a Cohen's D effect size was calculated using the formula: 'difference in means (intervention – control) / pooled SD' (Faraone, 2008). Two studies (Asplin et al., 2017; Ziden et al., 2010) provided median and range as raw data; this was converted to mean using the formula: '(minimum value + 2 x median + maximum value)/ 4' and SD using the formula: ‘(maximum value – minimum value)/ 4’ as suggested by Hozo et al. (2005), which were then converted into an effect size (Faraone, 2008). The effect size (standardised mean difference) was interpreted using Cohen’s guide as mentioned above (Cohen, 1988). One study provided only the between group differences (Taraldsen et al., 2019) and one study (Crotty et al., 2002) provided only median and 25^{th}/ 75^{th} percentiles as raw data. An effect size could not be calculated for these studies; so only the statistical significance of their result was provided as an estimate of the effectiveness of the intervention.

CHAPTER 3 RESULTS

3.1 Study selection

The search in the chosen databases yielded a total of 1113 records. 837 records remained after duplicates were removed. Following screening, 111 records were shortlisted for full-text review based on title and abstract. Finally, 32 articles (31 studies) met criteria and were eligible for inclusion; one of the studies was described in two separate articles (Ziden et al., 2010; Ziden et al., 2008). A further six potential studies were identified from reference list and forward citation checks; from these three were eligible for inclusion. Therefore, a total of 35 articles (34 studies) were included in this review. Five of these studies answered research question 1, two answered research question 2, fourteen answered research question 3, and thirteen answered research question 4. Figure 2 portrays the study screening and selection process. The main reasons for exclusion were 'no FoF measure performed or reported' and 'not answering one of the four research questions'. Ten studies were excluded due to a mixed population of participants with fractures other than hip fracture. Data for only the hip fracture participants in one RCT with a mixed population (Pfeiffer et al., 2020) was able to be obtained by contacting the author.

3.2 Characteristics of included studies

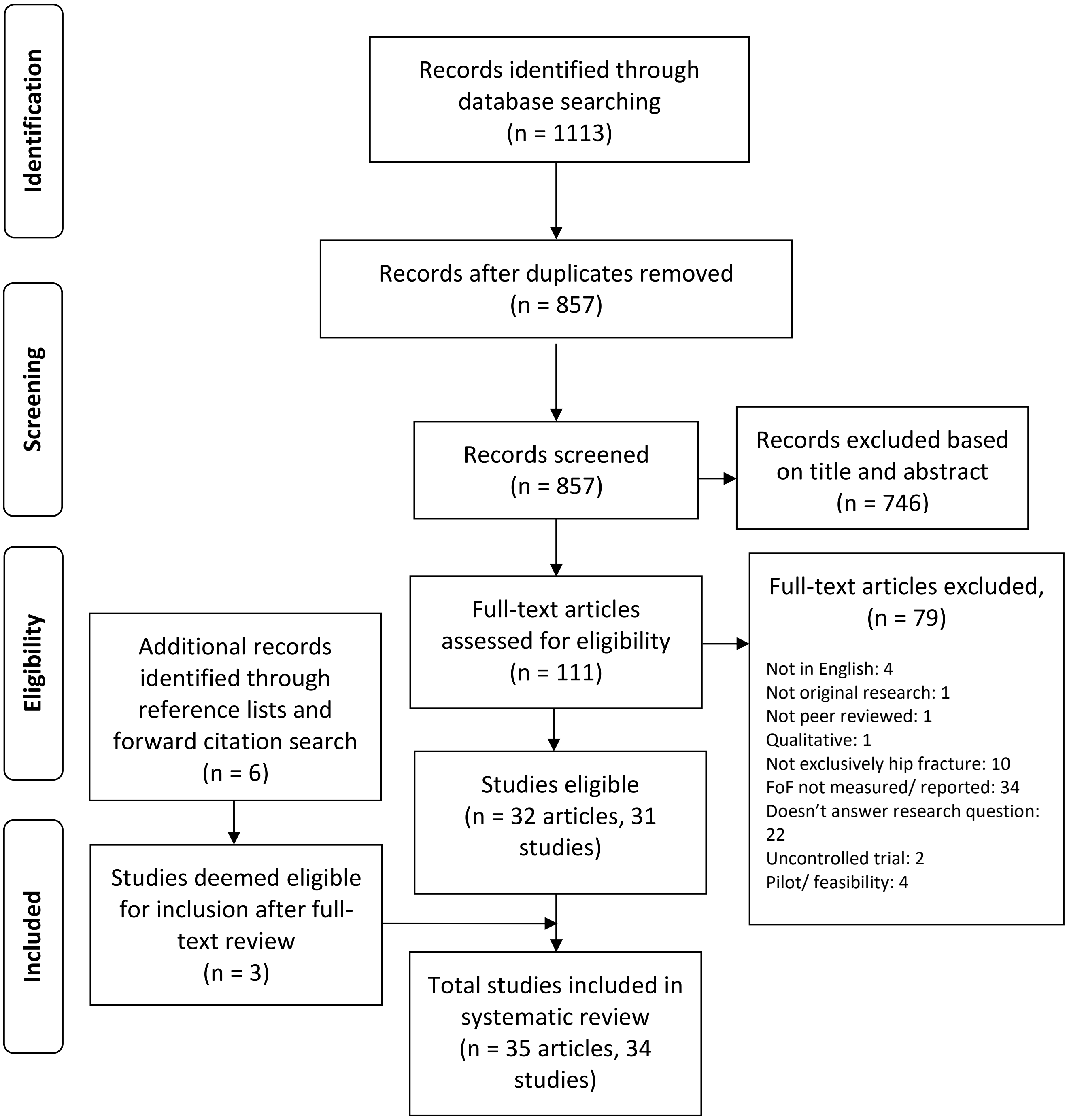
Tables 2, 4, 7 and 15 present the main descriptive data such as aims, study design, setting, sample size and participant characteristics, from included studies for each of the four research questions, respectively. The studies identified were contemporary, with most being published since 2010 (n = 2648) and some since 2000 (n = 1102); only one study was older (Ungar & Roger, 1986). Some studies took place in the acute hospital setting while others were undertaken in participants' homes or in the community. All studies included hip fracture patients (total 3809 participants across studies), usually older than 60 years of age. Female participants made up a greater proportion of the sample consistently across all studies. Common exclusion criteria seen in most studies were participants with cognitive impairment, need for assistance with mobility pre-fracture and presence of other co-morbidities. The days since hip fracture ranged widely (from within 1 week of hip fracture to 4 years post-fracture) across all included studies; but a number of studies did not report this.

3.3 Quality and risk of bias appraisal

All studies were critically appraised for their methodological quality using the chosen tools for each research question. This is presented in Tables 3, 6, 8 and 16 for each research question respectively, and the main appraisal findings are described in the sections that follow. Consensus was reached between the two reviewers for majority of questions in each tool. A third opinion was obtained for clarity on one occasion.

Figure 2

Flow chart showing study screening and selection process



3.4 Key Findings

The findings, including outcome measures used and statistical data as well as quality appraisals for each of the research questions are presented here.

3.4.1 Research Question One: Prevalence

A total of five studies were included that measured and reported FoF prevalence in hip fracture patients. Four were prospective cohort studies; one was cross-sectional in design. The main data extracted from these studies are presented in Table 2. The studies were performed in a hospital or post-acute rehabilitation setting.

Different tools were used to measure FoF prevalence across the studies. FoF was measured using the short FES-I by Bower et al. (2016), which consists of seven questions; prevalence was determined by dichotomising the score at a cut-off point of 11. This cut-off point was measured and recommended by Delbaere et al. (2010) to differentiate between low and high concern about falling. Other research studies (Bower et al., 2020; Jellesmark et al., 2012) have also used such cut-off points to measure FoF rates. Koeda et al. (2011); Kornfield et al. (2017) and Visschedijk et al. (2013) all used a single item question (SIQ) to measure prevalence but the wording of their measures differed (see Table 2). The study by Ungar and Roger (1986) did not report how it measured FoF.

Prevalence was measured at varying time points after hip fracture and the results are provided in Table 2 and presented in Figure 3. At 1-4 weeks post-fracture, FoF prevalence ranged between 50% – 100%, at ~12 weeks the range was between 47% – 59% and for the 12-58 week period it ranged between 23% – 50%. The scatter graph shows that FoF prevalence reduced as the time since hip fracture increased.

The quality appraisal of these studies using the ‘Risk of bias in prevalence studies’ tool is presented in Table 3. The study by Ungar and Roger (1986) was of poor quality and deemed as high risk of bias; all remaining studies had moderate risk of bias. A potential source of bias in all studies was that their samples were convenience samples and may not be representative of the wider hip fracture population. None of the studies reported use of random sampling to ensure that their sample selection method was bias free. Additionally, four out of five studies did not provide a clear case definition for FoF which introduces a bias as their results may not be reproducible. Only one study (Bower et al., 2016) used a validated and reliable instrument to measure FoF prevalence. Most studies used a SIQ which does not have proven validity and reliability in the literature (Jorstad et al., 2005; Scheffer et al., 2008). All studies except for Ungar and Roger (1986) did, however, use appropriate data collection and reporting methods.

Table 2

Study design, participant characteristics and data extracted for FoF prevalence studies

Study and Design	Main aims	Setting	Sample size (n)	Age (years) Mean ± SD if given	Gender (% female)	Time since hip fracture at recruitment, as reported	FoF measure to determine prevalence	RESULT Prevalence (%)
Bower (2016) *Prospective, longitudinal observational study*	To describe rates of FoF at 4 and 12 weeks post-fracture	8 Hospitals	Start: 299 End: 241	77.2 ± 8.5	74%	Within 1 week of fracture	sFES-I, dichotomised at score of ≥ 11/ 28 (classified as high FoF)	4 weeks: 60.5% 12 weeks: 47.0%
Koeda (2011) *Prospective study*	To study effects of FoF on physical function during acute phase	Hospital	Start: 46 End: 40	79.2 ± 6.4	100%	Within 1 week post-operatively	SIQ "Are you currently afraid of, or worried about falling?"	Week 1: 100% Week 4: 50.0%
Kornfield (2017) *Prospective, longitudinal study*	To explore rates and correlates of post-traumatic stress disorder	8 Hospitals	Start: 456 Week 4: 386 Week 12: 352	78.8 ± 8.7	77%	2 days after surgery	SIQ (Item 4 of FFQ) “I am afraid of falling again”	4 weeks: 66.6% 12 weeks: 58.5%
Ungar (1986) *Prospective study*	Not stated	Rehabilitation unit	Start: 72 End: 59	81.0	85%	‘After hospitalisation’, exact timeframe not reported	Not reported	2-6 months: 50.0% 6-12 months: 37.5% 12-15 months:

								22.5%
Visschedijk (2013) *Cross-sectional study*	To determine prevalence of FoF using different instruments	10 post-acute geriatric rehabilitation wards in nursing homes	100	83.1	75%	Within first two weeks after fracture	SIQ "Are you afraid of falling"	T1 (mean 21 days): 62.0% T2 (mean 42.2 days): 68.0% T3 (mean 87.7 days): 59.0%

FoF, fear of falling; SD, standard deviation; sFES-I, short falls efficacy scale international; SIQ, single item question; FFQ, fear of falling questionnaire

Figure 3

Prevalence of FoF among hip fracture patients

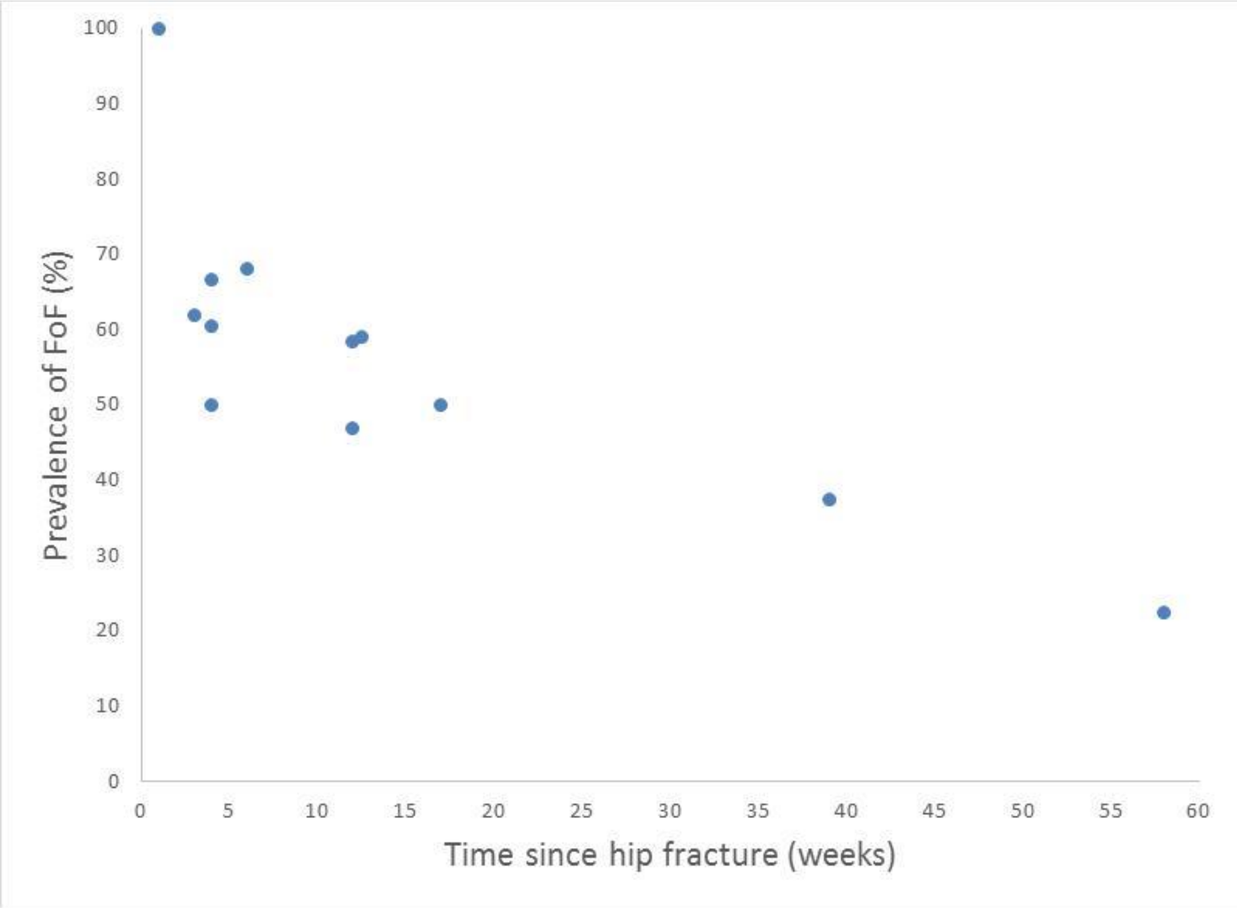


Table 3

Quality appraisal of prevalence studies using Risk of Bias in Prevalence Studies tool

Item	1	2	3	4	5	6	7	8	9	10	Overall
Study	Target population	Sampling frame	Random selection	Non-response bias minimal	Direct data collection	Acceptable case definition	Reliable/ valid instruments	Same mode of data collection	Length of prevalence period	Appropriate numerator/ denominator	Risk of bias
Bower (2016)	1	1	1	1	0	0	0	0	0	0	**Moderate Risk**
Koeda (2011)	1	1	1	0	0	1	1	0	0	0	**Moderate Risk**
Kornfield (2017)	1	1	1	0	0	1	1	0	0	0	**Moderate Risk**
Ungar (1986)	1	1	1	0	0	1	1	1	1	1	**High Risk**
Visschedijk (2013)	1	1	1	0	0	1	1	0	0	0	**Moderate Risk**

0 = Yes; 1 = No

Scoring: 0-3 Low Risk, 4-6 Moderate Risk, 7-9 High Risk (Hoy et al., 2012)

3.4.2 Research Question Two: Instrument Psychometrics

Only two eligible studies were found that measured the psychometric properties of FoF instruments in the hip fracture population. The data from these studies are presented in Table 4.

The first study (Bower et al., 2015) measured the psychometric properties of both a 15-item and a shorter 6-item version of the 'Fear of falling questionnaire revised' or FFQ-R (original FFQ was revised by expert clinicians). The FFQ-R is a self-report questionnaire on FoF with each item being scored on a Likert scale (1 – strongly disagree to 4 – strongly agree). The total possible scores range between 15 and 60 for the full 15-item version. The authors undertook post hoc analyses and accordingly removed items that showed poor correlation, which resulted in the 6-item version. This shorter version strongly correlated with the full 15-item FFQ-R ($r = 0.93$, $p < 0.001$).

This study recruited 405 hip fracture patients of 60 years or older, 2 days after their surgery, while excluding those with major depressive disorder, bipolar disorder or schizophrenia, moderate to severe cognitive impairment, and metastatic cancer. Results from this study are presented in Table 5. The 15-item and 6-item versions of the FFQ-R demonstrated acceptable and good internal consistency as well as excellent and good test-retest reliability, respectively. They also showed adequate construct validity as both were moderately correlated with the short FES-I and showed divergence from scores for depression and negative affect. Their factor analysis results for structural validity are detailed in Table 5.

The second study (Visschedijk et al., 2015) investigated the psychometric properties of the commonly used instrument of the FES-I (which focuses on fall-related efficacy and scores patients' concern about falling in relation to 16 activities of daily living) in hip fracture patients of 65 years or older. They excluded patients with communication issues or those unable to respond to the questions appropriately. The results of this study (see Table 5) show that the FES-I had excellent internal consistency and moderate inter-rater reliability. A standard error of measurement (SEM) of 6.4 was reported which is high for this scale where the total score can range from 16 to 64. The smallest detectable change (SDC) of 17.7 means that the score would need to change by 17.7 points to represent a true clinical change, not attributed to measurement error. Thus, the FES-I had substantial measurement error as acknowledged by the study (Visschedijk et al., 2015). As part of construct validity testing, only four out of 11 hypotheses were confirmed with the FES-I score found to be more closely correlated to measures of physical and functional performance (e.g. performance oriented mobility assessment and TUG test) than psychological constructs relating to fear, depression or anxiety. Thus, the construct validity testing suggests that this scale may not capture the emotional aspects of FoF but is better suited to measuring the functional performance aspects. The FES-I did not demonstrate any floor or ceiling effects.

The quality appraisal of these studies using the COSMIN tool is provided in Table 6. As shown, both studies scored well for the quality of their methods for 'internal consistency' and 'hypotheses testing for construct validity' testing. Visschedijk et al. (2015) did not score well for its 'measurement error' testing. Also, some concerns were raised for its 'structural validity' testing but the reason was probably minor (they did not report the rotation method for factor analysis). Both studies also scored poorly for 'reliability' testing, but some of the reasons were potentially unavoidable. For example, the time-frame between administrations for test-retest reliability was considered too short; however, in the rehabilitation context a longer timeframe could also be problematic due to the possibility for clinical change to occur. Additionally, Bower et al. (2015) excluded patients with certain conditions (as mentioned above), which reduces the generalisability of their findings to all hip fracture patients. The COSMIN tool did not account for this source of bias. Overall, the studies were reasonably well conducted.

Table 4

Study design and participants characteristics for studies on psychometric properties of FoF instruments

Study and Design	Main aim and Setting	Sample size (n)	Age (years) Mean ± SD	Gender (% female)	Time since hip fracture as reported
Bower (2015) *Psychometrics testing*	To test the psychometric properties of the FFQ-R (full 15-item version and a shorter 6-item version) *Hospital*	405 (16 for test-retest reliability)	78.0 ± 8.7	75%	Recruited approximately 2 days after surgery Measures taken at 4 weeks
Visschedijk (2015) *Psychometrics testing*	To test the psychometric properties of the FES-I in hip fracture patients *10 different Skilled Nursing Facilities in Netherlands*	Sample 1 100	83.1 ± 8.3	75%	44.5⁕ (28-63 range) (Visschedijk et al., 2014)
		Sample 2 21	83.2 ± 7.2	90%	3-4 weeks after admission to rehabilitation

FoF, fear of falling; SD, standard deviation; FFQ-R, fear of falling questionnaire revised; FES-I, falls efficacy scale international

⁕median

Table 5

Results of psychometric properties of the FFQ-R (15 and 6-item) and the FES-I

	Bower (2015)		Visschedijk (2015)
Psychometric property	**15-item FFQ-R**	**6-item FFQ-R**	**FES-I**
Internal Consistency	Acceptable, Cronbach's alpha 0.76, [0.73, 0.80 95%CI]	Good, Cronbach's alpha 0.80, [0.77, 0.83 95% CI]	Excellent, Cronbach's alpha = 0.94
Reliability	Test-retest Reliability – Excellent, ICC = 0.93, [0.85, 1.0 95%CI]	Test-retest Reliability – Good, ICC = 0.82, [0.65, 0.99 95%CI]	Inter-rater Reliability – Moderate, ICC = 0.72, [0.52, 0.87 95%CI]
Measurement Error	-	-	Substantial: SEM = 6.4 ; SDC = 17.7
Construct Validity	Convergent Validity – Adequate, hypothesis confirmed, Moderate correlation with sFES-I (r = 0.43) Divergent Validity – hypotheses confirmed, Weak correlation with MADRS (r = 0.25); Weak correlation with negative PANAS (r = 0.32)	Convergent Validity – Adequate, hypothesis confirmed, Moderate correlation with sFES-I (r = 0.42) Divergent Validity – hypotheses confirmed, Weak correlation with MADRS (r = 0.26); Weak correlation with negative PANAS (r = 0.34)	Construct validity – Questionable, 4 out of 11 hypotheses confirmed, strongest correlation with single item FoF instrument (r = 0.68). The FES-I correlated more closely with physical function compared to psychological scales.
Structural Validity	Using factor analysis found a 4 factor solution (threat, future expectancy, coping and harm)	Using factor analysis found a 2 factor solution (threat and harm)	Factor analysis: no item had a factor loading of ≤ 0.50, Strong evidence for uni-dimensionality of FES-I
Floor and Ceiling effects	-	-	Floor and Ceiling effects – none, 0% participants had maximum score and 1% had minimum score

FFQ-R, fear of falling questionnaire revised; FES-I, falls efficacy scale international; CI, confidence interval; ICC, intraclass correlation co-efficient; SEM, standard error of measurement; SDC, smallest detectable change; sFES-I, short falls efficacy scale international; MADRS, Montgomery asberg depression rating scale; PANAS, positive and negative affect schedule; r, Pearson or Spearman's correlation coefficient

Table 6

Quality appraisal of psychometrics studies using COSMIN tool

	Bower (2015)		Visschedijk (2015)
Item	**FFQ-R 15-item**	**FFQ-R 6 –item**	**FES-I**
PROM Design (1 – 35)	n/a	n/a	n/a
Content Validity (1 – 31)	n/a	n/a	n/a
Structural Validity			
1 Factor analysis	adequate	adequate	very good
2 Rasch model	n/a	n/a	n/a
3 Adequate sample size	very good	very good	adequate
4 Other design/ statistical flaws	very good	very good	doubtful
Overall	Adequate	Adequate	Doubtful
Internal Consistency			
1 Statistic calculated for each scale	very good	very good	very good
2 Continuous scores: Cronbach's alpha	very good	very good	very good
3 Dichotomous scores	n/a	n/a	n/a
4 'Item Response Theory' based scores	n/a	n/a	n/a
5 Other design/ statistical flaws?	very good	very good	very good
Overall	Very Good	Very Good	Very Good
Cross-cultural Validity (1-4)	n/a	n/a	n/a
Reliability			
1 Patients stable in interim period	adequate	adequate	doubtful
2 Appropriate time interval	inadequate	inadequate	inadequate
3 Similar testing conditions	doubtful	doubtful	very good
4 Continuous scores: ICC calculated	adequate	adequate	very good
5 Dichotomous scores	n/a	n/a	n/a
6 Ordinal scores: weighted kappa	n/a	n/a	n/a
7 Ordinal scores: weighting scheme	n/a	n/a	n/a
8 Other design/ statistical flaws	very good	very good	very good

Overall	Inadequate	Inadequate	Inadequate
Measurement Error	n/a	n/a	
1 Patients stable in interim period			doubtful
2 Appropriate time interval			inadequate
3 Similar testing conditions			very good
4 Continuous scores: SEM/ SDC			very good
5 Dichotomous scores			n/a
6 Other design/ statistical flaws			very good
Overall			Inadequate
Criterion Validity (1-3)	n/a	n/a	n/a
Hypotheses testing for Construct Validity			
1 Clear comparator instrument	very good	very good	very good
2 Measurement properties	very good	very good	very good
3 Appropriate statistical method	very good	very good	very good
4 Other design/ statistical flaws	very good	very good	very good
5 Adequate description of subgroups	very good	very good	n/a
6 Appropriate statistical method subgroups	very good	very good	n/a
7 Other design/ statistical flaws (subgroups)	very good	very good	n/a
Overall	Very Good	Very Good	Very Good
Responsiveness (1 -13)	n/a	n/a	n/a

FFQ-R, fear of falling questionnaire revised; FES-I, falls efficacy scale international; PROM, patient-reported outcome measure; n/a, not applicable; ICC, intraclass correlation coefficient; SEM, standard error of measurement; SDC, smallest detectable change

3.4.3 Research Question Three: Associations with measures of physical function or performance

Fourteen studies were included to answer research question 3. The main study and participant characteristics along with outcome measures used are given in Table 7. Most studies were cross-sectional with measurements taken at a single time-point, but three were prospective studies (Abel et al., 2020; Mckee et al., 2002; Oude Voshaar et al., 2006) with measurements taken at baseline and follow-up. The prospective study by Oude Voshaar et al. (2006) was run over a period of 6 months with statistical analysis undertaken to see if the baseline and 6 week FoF measure predicted other functional measures at 6 months. As seen in Table 7, most studies used instruments that focus on falls efficacy or balance confidence; the only measures of 'fear' were the FFQ-R in one study (Abel et al., 2020) and a SIQ in two studies (Ingemarsson et al., 2000; Mckee et al., 2002).

Most studies included participants with hip fracture that were 60 years of age or older. A common exclusion criterion was co-morbid illnesses such as progressive or neurological conditions. Also, at least 10 out of the 14 studies had a requirement for good cognitive function such as a Mini-mental State Exam (MMSE) score of > 23 for inclusion; three studies did not mention cognitive function in their inclusion/ exclusion criteria. Only one study allowed participants with mild to moderate cognitive impairment (MMSE 17-26) to be included (Abel et al., 2020). A majority of the studies also set inclusion criteria for good pre-fracture physical function (e.g. independently ambulatory) or residing in own home previously whilst excluding those that required assistance or lived in residential care. Thus, these studies tended to exclude patients with the poorest clinical features.

The time that had lapsed since hip fracture before the measurements were taken varied significantly between studies, ranging from immediately post-operatively up to a few years later. In some studies, this timeframe was not clearly stated. Some studies took place in acute hospital settings while others were in participants' homes or in the community. While it is difficult to amalgamate the results from these studies due to these variations, the results from these studies have been loosely categorized based on the type of measure utilised. These categories are 'balance', 'gait speed', 'composite physical performance', 'self-reported function', 'physical activity' and ‘muscle strength’. The strength of association or magnitude of effect size for all the reported results were assessed as described in the methodology section (presented for each category under each subheading below).

The quality appraisal of these studies using the modified AXIS tool is presented in Table 8. All studies scored well for items such as having clear aims and appropriate study designs as well as addressing ethics and consent requirements. Additionally, most studies used well-validated and reliable outcome measures. A common source of bias in these studies was that they did not control for potential confounding variables like age, co-morbidities, pre-fracture mobility/ function and falls history in their statistical analyses. Another potential source of bias was the selection process; most studies did not take measures to ensure that the sample was representative of all hip fracture patients as a number of them excluded participants with cognitive impairment or co-morbidities. Most studies also had small samples (see Table 7) and did not justify their sample size. Additionally, a large number of studies had low response rates for recruitment and did not appear to take measures to maximize their response rate. They also did not provide details regarding the characteristics of non-responders (compared to responders) which could inherently introduce bias.

Table 7

Study design, participant characteristics and outcome measures for FoF association studies

Study and Design	Main aims	Setting	Sample size (n)	Age (years) Mean ± SD	Gender (% female)	Time (days) since hip fracture: Mean ± SD	FoF measure	Physical function or performance measure(s)
Abel (2020) *Longitudinal Observational Study*	To explore predictors of change in physical performance	In-patient rehabilitation, follow-up at home	Start: 127 End: 102	84.7 ± 6.5	83%	Within last 3 months prior to recruitment Follow-up: 18.5⁕ (IQR 14 – 25 days)	sFES-I, FFQ-R	Change in physical performance calculated as absolute change in SPPB score (follow-up minus baseline)
Briggs (2018) *Cross-sectional study*	To investigate contribution of weight-bearing asymmetry during STS on physical function	Community	31	77.7 ± 10.5	68%	124.7 ± 42.6 (4.1 ± 1.4 months)	ABC	LEM, mPPT, SCT
Edgren (2013) *Cross-sectional study*	To investigate the associations between balance confidence, functional balance and physical disability	Community-dwelling	159	77.4 ± 7.2	73%	620.5 ± 766.5 (1.7 ± 2.1 years)	ABC (Finnish version)	BBS, Physical disability questionnaire
Ingermarsson (2000) *Cross-sectional study*	To investigate the relation between fall-related efficacy and balance	Hospital	55	82.3 ± 6.8	85%	25.3 ± 13.2 (post-surgery)	Swedish FES, SIQ "Are you afraid of falling?" with four-point ordinal scale	Sway index on balance platform, FR
Jellesmark (2012) *Interview - Cross sectional*	To investigate the association between FoF and functional	Community-dwelling	33	81.0⁕ (65-92	79%	Not reported (recruited 3	FES-I, mSAFE	FRS, NMS

	ability			range)		months post hospital discharge)		
Kline Mangione (2007) *Cross-sectional study*	To examine relationship of risk factors and impairments on the functional limitation of gait speed	Community, University research facility	42	79.2 ± 7.6	69%	122.5 ± 58.1 (17.5 ± 8.3 weeks)	ABC	Gait speed on Gait Mat II
Kneiss (2015) *Cross-sectional study*	To examine correlations between vGRF variables and specific clinical variables	Hospital and home care agency	29	80.4 ± 7.3	76%	79.1 ± 27.4 (2.6 ± 0.9 months)	ABC	Knee extension strength (involved and uninvolved sides)
Kronborg (2016) *Cross-sectional data within a Prospective Study*	To measure association between 24-hour upright time with FoF	Hospital	20	80.0 ± 8.4	78%	6.7 ± 2.4 (after surgery)	sFES-I	Time spent in sit/lie, standing and walking using ActivPal3 accelerometer
McKee (2002) *Prospective Observational Study*	To assess if FoF predicts health outcomes after falls	Hospital, follow-up at home	Start: 82 End: 57	80.2 ± 7.3	90%	Recruited 5-8 days after surgery Follow-up 2 months	Single question in interview (worry over further falls in the next two months, six point response scale), FES	FLP
Oude Voshaar (2006) *Longitudinal study (re-analysis of predictors from two RCTs)*	To prospectively examine the effect of FoF (at baseline and 6 weeks) on functional outcome at 6 months	4 orthopaedic units for baseline, follow-up at home	Start: 291 End: 187	79.8 ± 8.7	78%	Recruited within 2 weeks post-surgery Follow-up 6 weeks, 3 months and 6 months	mFES	TUG, gait speed, FR, SIP questionnaire

Portegis (2012) *Cross-sectional study*	To examine relationship between performance/ self-report mobility and balance measures	Community-dwelling	130	77.6 ± 7.2	75%	547.5 ± 730 (1.5 ± 2.0 years)	ABC (Finnish version)	BBS, 10MWT, mTUG, Self-reported mobility questionnaire, maximum voluntary knee extension strength
Sihvonen (2009) *Cross-sectional study*	To examine difference between hip fracture vs no fracture on balance/ balance confidence	Community, measurements done in laboratory or telephone interview	79	75.3 ± 6.7	68%	1542.8 ± 868 (4.2 ± 2.4 years)	ABC	BBS
Whitehead (2003) *Cross-sectional data within a Prospective Study*	To compare the four month outcomes of hip fracture patients	Community	73	81.3 ± 6.2	70%	Assessment done at 4 months after discharge from acute hospital	FES, ABC	BBS, LHS, Gait speed
Willems (2017) *Cross-sectional study*	To examine the relations between physical activity/ function and FoF	10 Skilled Nursing Facilities	100	83.1 ± 8.3	75%	44.5⁕ (28-63 range)	FES-I	Step count using pedometer, POMA

FoF, fear of falling; SD, standard deviation; IQR, interquartile range; sFES-I, short falls efficacy scale international; FFQ-R, fear of falling questionnaire revised; SPPB, short physical performance battery; STS, sit to stand; ABC, activities-specific balance confidence scale; LEM, lower extremity measure; mPPT, modified physical performance test; SCT, stair climb test; BBS, berg balance scale; FES, falls efficacy scale; SIQ, single item question; FR, functional reach test; FES-I, falls efficacy scale international; mSAFE, modified survey of activities and fear of falling; FRS, functional recovery score; NMS, new mobility score; vGRF, vertical ground reaction force; RFD, rate of force development; FLP, functional limitation profile; mFES, modified falls efficacy scale; TUG, timed up and go test; SIP, sickness impact profile; 10MWT, 10 metre walk test; mTUG, modified timed up and go test; LHS, London handicap scale; POMA, performance-oriented mobility assessment

⁕median

Table 8

Quality appraisal of association studies using modified AXIS tool

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Clear aims	Study design	Sample size	Clear population	Sampling Frame	Sample represented	Address Non-response	Appropriate Measures	Reliable/ valid measures	Statistical significance	Statistics described	Basic data	Response rate	Describe non-responders	Internally consistent	All results	Justified conclusion	Limitations given	Funding/ conflicts	Ethics/ consent	Blinded assessors	Loss to follow-up	Adjusted confounders
Abel (2020)	Y	Y	N	Y	Y	N	DK	Y	Y	Y	Y	Y	DK	N	Y	Y	Y	N	N	Y	DK	Y	Y
Briggs (2018)	Y	Y	N	Y	DK	N	DK	Y	Y	Y	Y	Y	DK	N	Y	Y	Y	Y	N	Y	DK	NA	N
Edgren (2013)	Y	Y	N	Y	Y	Y	DK	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	Y	DK	NA	N
Ingermarsson (2000)	Y	Y	N	N	Y	Y	DK	Y	Y	Y	N	Y	DK	N	Y	Y	N	N	N	DK	DK	Y	N
Jellesmark (2012)	Y	Y	N	Y	Y	N	DK	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N	Y	DK	NA	N
Kline Mangione (2007)	Y	Y	N	Y	DK	N	DK	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	Y	DK	NA	N
Kneiss (2015)	Y	Y	N	Y	Y	N	DK	Y	Y	Y	Y	Y	DK	N	Y	Y	Y	Y	DK	Y	DK	NA	N
Kronborg (2016)	Y	Y	N	Y	Y	N	DK	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	N
McKee (2002)	Y	Y	Y	Y	Y	Y	DK	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	DK	N	Y
Oude Voshaar	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	N	Y	N	Y	DK	N	Y

(2006)																							
Portegis (2012)	Y	Y	N	Y	Y	Y	DK	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	Y	DK	NA	Y
Sihvonen (2009)	Y	Y	N	Y	Y	N	DK	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	N	Y	DK	NA	N
Whitehead (2003)	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N	N	N	N	Y	Y	N	Y	N	Y	DK	NA	N
Willems (2017)	Y	N	N	Y	Y	N	DK	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	DK	Y	DK	NA	Y

Y, yes; N, no; DK, don’t know; NA, not applicable

Note: Two negatively worded questions # 13 and # 19. See Appendix B for tool

(a) Balance

Six studies, including one prospective study, reported on FoF association with balance measures. The most common measure was the Berg Balance Scale (BBS); four out of the six studies measured this and all reported the BBS to be associated with FoF measures (Table 9). The correlation (r) values ranged from 0.55 to 0.77 indicating a medium to large association (Cohen, 1988). Another balance measure used in two studies was the Functional Reach test, which was also reported to correlate (small to large magnitude) with FoF. Ingemarsson et al. (2000) investigated the correlation of FoF with sway index measured using a balance platform. They also reported a statistically significant, medium strength, correlation, between sway index (stable platform with eyes open testing conditions) and FoF measures.

The results from these studies demonstrate a consistent relationship between FoF and measures of balance. Lower FoF scores typically correlated with higher balance scores. The strength of bivariate associations was generally moderate to large. A single cross-sectional study (Portegijs et al., 2012) that performed multivariate regression analyses, revealed that balance confidence scores remained associated with balance measures in hip fracture patients after controlling for covariates (such as age, gender, level of physical activity). Another prospective study found that, FoF measured at 6 weeks predicted balance at 6 months post hip fracture (although with a negligible effect size); but baseline FoF was not related to balance at 6 months (Oude Voshaar et al., 2006).

Table 9

Results for association between FoF and balance measures

Study	Statistical method used	FoF outcome measure used	Balance outcome measure	Result: correlation co-efficient or regression value	Strength of association and/or interpretation
Edgren (2013)	Spearman's Correlation	ABC (Finnish version)	BBS	r = 0.69∗	Large, Higher balance confidence was associated with better balance
Ingemarsson (2000)	Spearman's Correlation	Swedish FES	Sway on Balance Platform	r = -0.42∗	Medium, Lower falls efficacy was associated with worse balance
		SIQ	Sway on Balance Platform	r = 0.34∗	Medium, FoF was associated with worse balance
		Swedish FES	FR	r = 0.53∗	Large, Lower falls efficacy was associated with lower FR score
		SIQ	FR	r = -0.20ns	Small, FoF was not significantly associated with FR score
Oude Voshaar (2006) Longitudinal	Multiple Logistic Regression	mFES (baseline FoF)	FR at 6 months	OR = 1.06ns (0.92-1.21 95% CI) ES = 0.03	Baseline FoF did not predict FR score at 6 months, after controlling for covariates (age, intervention received and pre-morbid function)
		mFES at 6 weeks	FR at 6 months	OR = 1.32∗ (1.08-1.60 95% CI) ES = 0.15	FoF at 6 weeks predicted FR score at 6 months, after controlling for covariates; statistically significant but negligible effect size
Portegis (2012)	Spearman's Correlation	ABC (Finnish version)	BBS	r = 0.72∗	Large, Higher balance confidence was associated with better balance

	Multiple Logistic Regression (Sensitivity analysis)	For ABC score of <85	BBS	OR 12.60 (5.30-29.80 95% CI) ES = 1.40	Large, Those with an ABC score of <85 (lower balance confidence) were 12.6 times more likely to have a lower BBS score
Sihvonen (2009)	Not specified	mABC	BBS	r = 0.74 (statistical significance not stated)	Large, Higher balance confidence was associated with better balance
Whitehead (2003)	Spearman's Correlation	FES	BBS	r = 0.55∗	Large, Higher falls efficacy was associated with better balance
		mABC	BBS	r = 0.77∗	Large, Higher balance confidence was associated with better balance

FoF, fear of falling; ABC, activities-specific balance confidence scale; BBS, berg balance scale; FES, falls efficacy scale; SIQ, single item question; FR, functional reach test; mFES, modified falls efficacy scale; OR, odds ratio; CI, confidence interval; ES, effect size; mABC, modified activities-specific balance confidence scale

∗ statistically significant; ns statistically non-significant

(Cohen, 1988)

(b) Gait speed

This category was for any instrument that measured gait speed (results provided in Table 10). Five studies reported findings on gait speed and all reported gait speed to significantly correlate with their chosen FoF measure. The r values ranged between 0.38 to 0.65 (medium to large strength) using simple, bivariate associations. Using multivariate regression and controlling for potential confounding variables including age, gender, co-morbidities and level of physical activity, Portegijs et al. (2012) found a strong result with a large odds ratio of 6.3. In other words, participants with lower balance confidence (score of <85 on the ABC) were 6.3 times more likely to be categorised as having slow gait speed. In contrast, using stepwise regression, Kline Mangione et al. (2007) showed that balance confidence explained only 3.5% variance in gait speed, although this was still statistically significant. The only prospective study found that FoF measured at 6 weeks predicted gait speed at 6 months post hip fracture (although with a negligible effect size); but baseline FoF did not. Overall, these findings show that higher FoF is consistently associated with slower gait speed.

Table 10

Results for association between FoF and gait speed measures

Study	Statistical method used	FoF outcome measure used	Gait speed outcome measure	Result: correlation co-efficient or regression value	Strength of association and/or interpretation
Kline Mangione (2007)	Pearson Correlation	ABC	Gait speed on Gait Mat II	r = 0.61∗	Large, Higher balance confidence was associated with faster gait speed
	Stepwise Regression			r^2 = 0.035∗, Standardised Beta Coefficient = 0.222, partial correlation = 0.332	Balance confidence explained 3.5% of the variance in gait speed after controlling for covariates
Kronborg (2016)	Spearman's Correlation	sFES-I	10MWT	r = -0.50∗	Large, Higher falls efficacy (less FoF) was associated with faster gait speed
Oude Voshaar (2006) Longitudinal	Multiple Logistic Regression	mFES (baseline FoF)	Gait speed at 6 months	OR = 0.93ns (0.82-1.04 95% CI) ES = 0.04	Baseline FoF did not predict gait speed at 6 months, after controlling for covariates
		mFES at 6 weeks	Gait speed at 6 months	OR = 0.73∗ (0.62-0.86 95% CI) ES = 0.17	FoF at 6 weeks predicted gait speed at 6 months, after controlling for covariates; statistically significant but negligible effect size
Portegis (2012)	Pearson Correlation	ABC (Finnish version)	10MWT	r = 0.51∗	Large, Higher balance confidence was associated with faster gait speed

	Multiple Logistic Regression	For ABC score of <85	10MWT	OR 6.30∗ (2.60 - 15.00 95% CI) ES = 1.02	Large, Those with an ABC score of <85 (lower balance confidence) were 6.3 times more likely to have slower gait speed
Whitehead (2003)	Spearman's Correlation	FES	Gait speed	r = 0.38∗	Medium, Higher falls efficacy was associated with faster gait speed
		ABC	Gait speed	r = 0.65∗	Large, Higher balance confidence was associated with faster gait speed

FoF, fear of falling; ABC, activities-specific balance confidence scale; sFES-I, short falls efficacy scale international; 10MWT, 10 metre walk test; mFES, modified falls efficacy scale; OR, odds ratio; CI, confidence interval; ES, effect size

∗ statistically significant; ns statistically non-significant

(Cohen, 1988)

(c) Composite physical performance measures

Outcome measures that objectively tested participants on more than one aspect of physical performance such as a combination of mobility and balance tasks were categorised as composite physical performance measures. Such measures were reported in six studies. All studies that performed simple correlations found a significant correlation between FoF and respective composite measures (as shown in Table 11) with a strong correlation in three studies and medium correlation in one study. Two cross-sectional studies performed multivariate regression; one study (Briggs et al., 2018) found that balance confidence explained some variance in composite measures even after controlling for covariates (see Table 11); the other study showed that those with lower balance confidence (score of <85 on the ABC) were 7.3 times more likely to be slower on the TUG test (Portegijs et al., 2012). Two prospective studies found that FoF does predict performance in these measures at less than 1 month (Abel et al., 2020) to 6 months (Oude Voshaar et al., 2006). Both results were statistically significant but one was of medium strength while the other had a negligible effect size (as outlined in Table 11). Overall, these findings show that lesser FoF is associated with better performance in composite physical performance measures.

Table 11

Results for association between FoF and composite physical performance measures

Study	Statistical method used	FoF outcome measure used	Composite outcome measure	Result: correlation co-efficient or regression value	Strength of association and/or interpretation
Abel (2020) Prospective	Univariate Regression	sFES-I	Δ SPPB at follow-up (< 1 month)	sFES-I did not predict Δ SPPB, so not entered into the multiple regression model, raw statistic not reported	-
	Multiple Linear Regression	FFQ-R	Δ SPPB at follow-up (< 1 month)	Standardised Beta coefficient = -0.279∗, Calculated r = -0.329 (Peterson & Brown, 2005)	Medium, Lower baseline FoF predicted improvement in physical performance, after controlling for covariates
Briggs (2018)	Pearson Correlation	ABC	mPPT	r = 0.77∗	Large, Higher balance confidence was associated with better physical performance
	Hierarchical Regression			Standardised Beta coefficient = 0.61∗, Part correlation = 0.32	Balance confidence explained 10.4% of the variance in physical performance after controlling for covariates
	Pearson Correlation	ABC	SCT	r = -0.65∗	Large, Higher balance confidence was associated with faster stair climb
	Hierarchical Regression			Standardised Beta coefficient = -0.37∗, Part correlation = -0.20	Balance confidence explained 3.8% of the variance in stair climb after controlling for covariates
Kronborg (2016)	Spearman's Correlation	sFES-I	TUG	r = 0.54∗	Large, Lesser FoF was associated with faster TUG test time
Oude Voshaar (2006) Longitudinal	Multiple Logistic Regression	mFES (baseline)	TUG at 6 months	OR = 0.89∗ (0.80-0.99 95% CI) ES = 0.06	Baseline FoF predicted TUG score at 6 months, after controlling for covariates; statistically significant but negligible effect size

		mFES at 6 weeks	TUG at 6 months	OR = 0.75∗ (0.64-0.88 95% CI) ES = 0.16	FoF at 6 weeks predicted TUG score at 6 months, after controlling for covariates; statistically significant but negligible effect size
Portegis (2012)	Spearman's Correlation	ABC (Finnish version)	mTUG	r = -0.56∗	Large, Higher balance confidence was associated with faster mTUG score
	Multiple Logistic Regression	For ABC score of <85	mTUG	OR 7.30* (3.00 - 17.80 95% CI) ES = 1.10	Large, Those with an ABC score of <85 (lower balance confidence) were 7.3 times more likely to be slower on the mTUG
Willems (2017)	Spearman's Correlation	FES-I	POMA	r = 0.43∗	Medium, Higher falls efficacy was associated with higher physical performance

FoF, fear of falling; sFES-I, short falls efficacy scale international; FFQ-R, fear of falling questionnaire revised; Δ SPPB, change in short physical performance battery (follow-up minus baseline); ABC, activities-specific balance confidence scale; mPPT, modified physical performance test; SCT, stair climb test; TUG, timed up and go test; mFES, modified falls efficacy scale; OR, odds ratio; CI, confidence interval; ES, effect size; mTUG, modified timed up and go test; FES-I, falls efficacy scale international; POMA, performance-oriented mobility assessment

∗ statistically significant

(Cohen, 1988)

(d) Self-reported function

A total of five studies used self-report questionnaires of mobility and function where participants were asked to rate or score their own mobility/ function. In other words, this was a self-perceived report by the participant of their ability to perform functional tasks. All studies found a significant bivariate correlation between FoF and self-reported function, with the strength of the correlation being large in three cross-sectional studies and medium in a prospective study (Mckee et al., 2002); there was only one non-significant correlation (see Table 12). Overall, higher FoF was associated with lower self-reported function. Using multiple regression, Portegijs et al. (2012)

found a strong relationship between balance confidence and self-reported function with a large effect size, after controlling for covariates. Edgren et al. (2013) also found a significant association as outlined in Table 12. Of the two prospective studies, one found that FoF did not predict self-reported function 2 months after hip fracture (Mckee et al., 2002) while the other found that FoF did predict self-reported mobility and activity 6 months post-fracture, although the effect size was small or negligible (Oude Voshaar et al., 2006). Therefore, based on these results, FoF is typically correlated with self-reported function when assessed at the same time point, but its ability to predict future self-reported function may be limited.

Table 12

Results for association between FoF and self-reported function measures

Study	Statistical method used	FoF outcome measure used	Self-reported function outcome measure	Result: correlation co-efficient or regression value	Strength of association and/or interpretation
Edgren (2013)	Negative Binomial Regression (generalisation of Poisson Regression)	ABC (Finnish version)	Physical Disability questionnaire (for both ADL and IADL)	IRR 0.99∗, (0.98-0.99 95% CI), $p < 0.001$	For every 10 point increase in ABC score (higher balance confidence), ADL and IADL disability score reduced by 10%
Jellesmark (2012)	Spearman's Correlation	FES-I	FRS	$r = -0.78$∗	Large, Higher falls efficacy was associated with lesser need for assistance with functional tasks
		mSAFE	FRS	$r = -0.80$∗	Large, Higher score on mSAFE (greater avoidance of activities) was associated with worse function
		FES-I	NMS	$r = -0.67$∗	Large, Lower score on FES-I (lower FoF) was associated with higher score on NMS (better mobility)

		mSAFE	NMS	r = -0.74∗	Large, Higher score on mSAFE (greater avoidance of activities) was associated with lower score on NMS (worse mobility)
Mckee (2002) Prospective	Spearman's Correlation	FES (baseline)	FLP at 2 months	r = -0.37∗	Medium, baseline FoF correlated with function at 2 months
		SIQ (worry over further falls)	FLP at 2 months	r = 0.18ns	Small, Worry over falling as measured by a SIQ did not correlate with function at 2 months
	Hierarchical Linear Regression	FES (baseline)	FLP at 2 months	Standardised Beta coefficient = -0.16ns, $r^2 = 0.05$	After controlling for covariates, FES score did not predict functional limitations and explained 5% of its variance
Oude Voshaar (2006) Longitudinal	Multiple Logistic Regression	mFES (baseline)	SIP (mobility section) at 6 months	OR = 0.92∗ (0.83-1.02 95% CI), p = 0.11 ES = 0.04	Baseline FoF predicted SIP mobility at 6 months, after controlling for covariates; statistically significant but negligible effect size
		mFES at 6 weeks	SIP mobility at 6 months	OR = 0.70∗ (0.60-0.81 95% CI), p < 0.001 ES = 0.20	FoF at 6 weeks predicted SIP mobility at 6 months, after controlling for covariates, small effect size
		mFES (baseline)	SIP (activity section) at 6 months	OR = 0.90∗ (0.81-1.00 95% CI), p = 0.05 ES = 0.06	Baseline FoF predicted SIP activity at 6 months, after controlling for covariates; statistically significant but negligible effect size
		mFES at 6 weeks	SIP activity at 6 months	OR = 0.71∗ (0.61-0.82 95% CI), p < 0.001 ES = 0.19	FoF at 6 weeks predicted SIP activity at 6 months, after controlling for covariates; statistically significant but negligible effect size
Portegis (2012)	Spearman's Correlation	ABC (Finnish version)	Self-reported mobility questionnaire: ability to walk outdoors	r = -0.54∗	Large, Higher balance confidence was associated with higher self-reported mobility

	Multiple Logistic Regression	For ABC score of <85	Self-reported mobility questionnaire: ability to walk outdoors	OR 18.7 (6.00-58.00 95% CI) ES = 1.62	Large, Those with an ABC score of <85 (lower balance confidence) were 18.7 times more likely to report difficulty with outdoor walking
	Spearman's Correlation	ABC (Finnish version)	Self-reported mobility questionnaire: stair climb	r = -0.57∗	Large, Higher balance confidence was associated with better self-reported stair climb
	Multiple Logistic Regression	For ABC score of <85	Self-reported mobility questionnaire: stair climb	OR 11.7 (4.60-29.90 95% CI) ES = 1.36	Large, Those with an ABC score of <85 (lower balance confidence) were 11.7 times more likely to report difficulty with stair climbing
Whitehead (2003)	Spearman's Correlation	FES	LHS	r = 0.62∗	Large, Higher FES score (greater falls efficacy) was associated with higher LHS score (lower handicap)
		ABC	LHS	r = 0.80∗	Large, Higher balance confidence was associated with higher LHS score

FoF, fear of falling; ABC, activities-specific balance confidence scale; ADL, activities of daily living; IADL, instrumental activities of daily living; IRR, incidence rate ratio; FES-I, falls efficacy scale international; mSAFE, modified survey of activities and fear of falling; FRS, functional recovery score; NMS, new mobility score; FES, falls efficacy scale; SIQ, single item question; FLP, functional limitation profile; mFES, modified falls efficacy scale; SIP, sickness impact profile; OR, odds ratio; CI, confidence interval; ES, effect size; LHS, London handicap scale

∗ statistically significant; ns statistically non-significant

(Cohen, 1988)

(e) Physical activity

This category was for measures that quantify physical activity e.g. using a pedometer or accelerometer. Only two studies measured this; one measured time spent being physically active using an accelerometer while the other measured step count using a pedometer. The results are given in Table 13 and show that lower FoF had a medium strength correlation with higher physical activity (using bivariate correlations). This relationship was also significant (although negligible effect size) in univariate regression analysis, however, it did not remain significant after controlling for covariates in multivariate regression in the study that analysed this (Willems et al., 2017). There were no prospective studies in this category. Thus, the relationship between FoF and physical activity remains uncertain, with limited evidence that higher FoF is related to decreased physical activity.

Table 13

Results for association between FoF and physical activity measures

Study	**Statistical method used**	**FoF outcome measure used**	**Physical activity outcome measure**	**Result: correlation co-efficient or regression value**	**Strength of association and/or interpretation**
Kronborg (2016)	Spearman's Correlation	sFES-I	Time spent in sitting, lying, standing or walking using accelerometer	r = -0.48∗	Medium, Lesser FoF was associated with more upright time at discharge
Willems (2017)	Spearman's Correlation	FES-I	Step count using pedometer	r = 0.34∗	Medium, FES-I score correlated with step count
	Univariate Logistic Regression			OR = 0.94∗ (0.89-0.99 95% CI) ES = 0.03	FoF was associated with step count but negligible effect size
	Multivariate Logistic Regression			ns, raw statistic not reported	FoF was not associated with step count after controlling for covariates

FoF, fear of falling; sFES-I, short falls efficacy scale international; FES-I, falls efficacy scale international; OR, odds ratio; CI, confidence interval; ES, effect size

∗ statistically significant; ns statistically non-significant

(Cohen, 1988)

(f) Muscle strength

Studies that reported on a measure of muscle strength were included in this category. Only two studies reported such measures and both focused on quadriceps strength. Results are provided in Table 14. The findings of these studies show that balance confidence was associated with quadriceps strength of both the affected (hip fracture side) and non-affected limb, with medium to large correlation coefficients. No studies attempted to control for potential confounding factors and no prospective study measured this association. Thus, there is limited evidence that higher FoF may be related to reduced quadriceps strength in both the injured and uninjured limb.

Table 14

Results for association between FoF and muscle strength measures

Study	Statistical method used	FoF outcome measure used	Muscle strength outcome measure	Result: correlation co-efficient or regression value	Strength of association and/or interpretation
Kneiss (2015)	Pearson Correlation	ABC	Knee extension strength, involved side	r = 0.55∗	Large, Higher balance confidence was associated with greater knee strength of the affected lower limb
			Knee extension strength, uninvolved side	r = 0.52∗	Large, Higher balance confidence was associated with greater knee strength of the non-affected lower limb
Portegis (2012)	Pearson Correlation	ABC (Finnish version)	Maximum voluntary knee extension strength (affected lower limb)	r = 0.40∗	Medium, Higher balance confidence was associated with greater knee strength of the affected lower limb

FoF, fear of falling; ABC, activities-specific balance confidence scale

∗ statistically significant

(Cohen, 1988)

3.4.4 Research Question Four: Interventions

Thirteen studies (fourteen articles; Ziden et al. (2008) and Ziden et al. (2010) were a follow-up of the same sample and intervention) were included that assessed effects of an intervention on FoF. Most studies included FoF as a secondary measure; only five studies had a primary aim of reducing FoF (Crotty et al., 2002; Pfeiffer et al., 2020; Scheffers-Barnhoorn et al., 2019; Van Ooijen et al., 2016; Ziden et al., 2008). Most of the studies were RCTs but there was one study with a quasi-experimental pre-test post-test design (Ko et al., 2019) and one non-randomised controlled intervention study (Asplin et al., 2017).

The main characteristics and data extracted from these studies are given in Table 15. Some trials were carried out in the acute hospital setting while others were in the sub-acute or community setting. However, most studies did not clearly report the number of days since hip fracture. The inclusion and exclusion criteria varied across studies, but some common features were exclusion of cognitively impaired, physically dependent and co-morbid participants. The average participant age in most studies was in the early 80s and 60 – 90% of participants were female.

The studies have been categorized based on the type of intervention as follows: exercise based, psychologically based, multi-component (commonly combining exercise and psychological intervention strategies), accelerated or supported discharge, and other. The interventions and their findings under each category are described below, along with the data analysis performed (as described in the methodology section). Where possible, effect sizes were calculated to aid in interpretation. Data regarding minimal clinically important difference (MCID) are unavailable for most FoF instruments with only some data available for the FES-I (Halvarsson et al., 2013; Morgan et al., 2013) and modified FES or mFES (Kwok & Pua, 2016). Where available, data regarding MCID were used to determine the likely clinical relevance for statistically significant results.

The methodological quality appraisal of these intervention studies was carried out using the RoB2 tool (Sterne et al., 2019). This is presented in Table 16 and portrayed in Figure 4. Overall, four studies achieved ‘some concern’ and the remaining nine studies achieved ‘high risk of bias’ on the RoB2. As seen in Figure 4, the main sources of bias in these studies were identified in the first three categories of the RoB2 tool. Studies scored high risk in ‘randomisation process’ due to inadequate allocation concealment and/or baseline differences between groups, in ‘deviations from intended intervention’ due to non-blinded participants and clinicians as well as lacking an intention-to-treat analysis, and in ‘missing outcome data’ due to potential bias introduced from participants lost to follow-up. Studies performed better in ‘measurement of the outcome’ as they used appropriate validated measures; however, non-blinded assessors were a source of bias. Lastly, many studies did not provide information about a pre-specified analysis plan which raised some concerns in the ‘selection of the reported result’ category of the RoB2. Most of these sources of bias could be expected to favour the intervention group.

While most studies undertook a power calculation to justify their sample size, few explicitly calculated this in relation to their FoF measure. The follow-up period ranged from two weeks to one year across studies, however, only three studies had a longer follow-up of one year.

Table 15

Study design, participant characteristics and intervention/ control group and follow-up details for FoF intervention studies

Study and Design	Setting	Sample size (n)	Age (years), Mean ± SD	Gender (% female)	Time since hip fracture/ surgery, Mean ± SD unless stated otherwise	Follow-up time-point(s)	Loss to follow-up/ drop-out rate (%)
EXERCISE BASED							
Beckmann (2021) *Parallel-group, pseudo-RCT*	Nursing homes after hospital discharge	IG: Health professional led functional exercise programme in addition to usual care. Up to 4 times daily, 7 days a week for 2 weeks			Not reported (recruited during sub-acute rehabilitation)	2 weeks and 3 months	None
		78	84.8 ± 7.2	81%			
		CG: Usual Care and physiotherapy					
		62	85.5 ± 7.1	81%			
Taraldsen (2019) *RCT, stratified*	Home, community	IG: 2 exercise sessions (PT led, balance and gait) per week for 10 weeks in addition to usual care			4 months post-surgery	2 and 8 months	21%
		70	84.0 ± 6.6	77%			
		CG: Usual care and rehabilitation					
		73	82.7 ± 5.7	77%			
van Ooijen (2016) *RCT, parallel group*	Discharge from hospital to a Residential and Rehabilitation Centre	AT: 15 sessions of adaptability treadmill training and 15 sessions of usual physiotherapy over 6 weeks			13⁕ (7-65 range) days	4 weeks and 12 months	51%
		24	82.9 ± 6.5	67%			
		CT: 15 sessions of treadmill walking and 15 sessions of			13⁕ (6-63 range)		

		usual physiotherapy			days		
		23	83.9 ± 5.5	61%			
		CG: 30 sessions of usual physiotherapy			14* (7-79 range) days		
		23	83.3 ± 8.0	91%			
PSYCHOLOGICALLY BASED							
O'Halloran (2016) *RCT*	Participant's home, community	IG: Motivational Interviewing (1 x 30 minute session per week over 8 weeks) in addition to usual care			183 ± 63 days	9 weeks	17%
		13	83.0 ±4.8	85%			
		CG: Usual care					
		12	82.3 ± 5.7	83%			
MULTI-COMPONENT (COMBINED EXERCISE AND PSYCHOLOGICAL INTERVENTIONS)							
Asplin (2017) *Prospective, controlled, intervention study*	In-patient rehabilitation ward	IG: Psychological component: enhanced OT/PT collaboration, goal setting, supporting patient self-efficacy. Physical component: training kit with instructions, enhanced exercise with protocol, collaboration meetings.			Not reported, but acute, immediately post-operative	Discharge, 1 month	16%
		63	82.0 ± 8.0	75%			
		CG: Standard rehabilitation from OT/ PT					
		63	80.5 ± 7.7	78%			
Pfeiffer (2020) *RCT, extracted data for hip fracture patients only as*	Recruited from in-patient rehabilitation but seen for intervention approx. 2	IG: Eight individual sessions incorporating CBT with balance and strength exercise and four telephone calls and one home visit post-discharge (in addition to usual rehabilitation care), provided by PT who was supervised			Not reported approx. 8 weeks	Before discharge, 3 months	16%

obtained from lead author	months post-discharge	by a clinical psychologist				after discharge	
		42	82.3 ± 6.5	76%			
		CG: Usual rehabilitation for 3 weeks, no further contact after discharge					
		51	82.2 ± 6.6	73%			
Scheffers-Barnhoorn (2019) *RCT, cluster*	11 Geriatric Rehabilitation (in-patient) units	IG: 'FIT-HIP' consisting of CBT elements aimed at reducing FoF (psycho-education, guided exposure to feared activities, cognitive restructuring) integrated with physiotherapy and exercise sessions, provided by PT trained and supported by psychologist			Not reported, but immediate/ acute	Discharge, 3 and 6 months	36%
		39	83.7 ± 7.3	87%			
		CG: Usual multi-disciplinary rehabilitation, including 5-6 physiotherapy sessions per week					
		38	81.3 ± 7.9	71%			
ACCELERATED/ SUPPORTED DISCHARGE							
Crotty (2002) *RCT*	Home after hospital discharge	IG: Accelerated discharge and home-based rehabilitation including initial home visit to address home modifications/ equipment installation, then follow-up visits from PT/OT and other MDT			Not reported, but immediate/ acute	4 months	None
		34	81.6⁕	62%			
		CG: Usual rehabilitation care in hospital					
		32	83.5⁕	75%			
Lockwood (2019) *RCT*	Acute and rehabilitation ward, hospital	IG: Single home visit by OT (participant present on visit) with education, advice, home adaptations, in addition to usual care			Not reported, acute, immediate post-operation	30 days and 6 months	23%

			37	83.4 ± 7.1	76%			
		CG: Usual MDT rehabilitation care						
			40	80.9 ± 7.3	68%			
Ziden (2008) and Ziden (2010) *RCT*	Home after hospital discharge	IG: Home rehabilitation comprising supported discharge (goal setting, motivation and self-efficacy actions, home services and relatives involved, PT/OT accompanied participant to go home at discharge, follow-up home visits for 3 weeks to advance rehabilitation)				Not reported, but immediate, acute at time of recruitment	1, 6 and 12 months after discharge	9%
			48	81.2 ± 5.9	60%			
		CG: Usual MDT rehabilitation care						
			54	82.5 ± 7.6	78%			
OTHER								
Birks (2003) *RCT*	Community-dwelling	IG: Three pairs of hip protectors issued and general advice leaflet on how to reduce fracture risk				Not reported, any time, no restrictions	6 weeks and 6 months	24%
			182	80.8 ± 6.0	87%			
		CG: Leaflet only						
			184	80.2 ± 5.7	88%			
Ko (2019) *Quasi-experimental, pre-test post-test design, with non-equivalent control group*	Orthopaedic ward, hospital	IG: Individualised transitional care programme: nurse led, primarily educational programme via booklets, observation, demonstration and therapeutic communication (included goal setting, emotional support, positive reinforcement), 6 times for 2 weeks				Not reported, but immediate, acute	1-2 days before discharge	8%
			18	75.5 ± 3.7	78%			

		CG: Usual post-operative care plus booklets					
		16	77.9 ± 5.4	81%			
Peichl (2005) *RCT, parallel group*	Rehabilitation ward, hospital	IG: 200IU salmon calcitonin nasal spray twice daily for 12 months in addition to 1000mg calcium and 880IU vitamin D daily			Not reported, but acute, post-operative	12 months	35%
		37	78.9 ± 6.3	100%			
		CG: 1000mg calcium and 880IU vitamin D daily for 12 months					
		38	76.9 ± 3.9	100%			

FoF, fear of falling; SD, standard deviation; RCT, randomised controlled trial; IG, intervention group; CG, control group; PT, physiotherapist; OT, occupational therapist; CBT, cognitive behavioural therapy; MDT, multi-disciplinary team

⁕ median

Table 16

Quality appraisal of intervention studies using RoB2

	Asplin (2017)	Beckmann (2021)	Birks (2003)	Crotty (2002)	Ko (2019)	Lockwood (2019)	O'Halloran (2016)	Peichl (2005)	Pfeiffer (2020)	Scheffers-Barnhoorn (2019)	Taraldsen (2019)	van Ooijen (2016)	Ziden (2008) Ziden (2010)
1.1 Randomised	N	PN	Y	Y	N	Y	Y	NI	Y	Y	Y	NI	NI
1.2 Allocation concealed	N	PY	Y	Y	N	Y	Y	NI	PY	N	PY	NI	N
1.3 Baseline differences	N	Y	PN	N	N	PN	PN	PN	PN	Y	PN	Y	N
ROB	H.R.	S.C.	L.R.	L.R.	H.R.	L.R.	L.R.	S.C.	L.R.	H.R.	L.R.	H.R.	H.R.
2.1 Participant not blinded	PY	Y	Y	Y	PY	Y	Y	Y	Y	PN	Y	Y	PY
2.2 Clinician not blinded	PY	Y	PY	PY	PY	Y	Y	Y	Y	Y	Y	Y	PY
2.3 Deviation from intervention	NI	NI	NI	NI	NI	PN	N	NI	NI	NI	Y	PN	NI
2.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	PY	NA	NA
2.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N	NA	NA
2.6 Intention-to-treat	NI	Y	NI	Y	N	Y	N	PN	Y	Y	Y	N	N
2.7	PY	NA	PY	NA	NI	NA	NA	PN	NA	NI	PN	PN	Y
ROB	H.R.	S.C.	H.R.	S.C.	H.R.	L.R.	H.R.	S.C.	S.C.	S.C.	H.R.	S.C.	H.R.
3.1 All data	N	N	N	PY	PN	N	N	PN	N	N	N	N	N
3.2 Bias by	N	Y	PN	NA	PN	PY	PN	N	Y	PN	PN	PN	PN

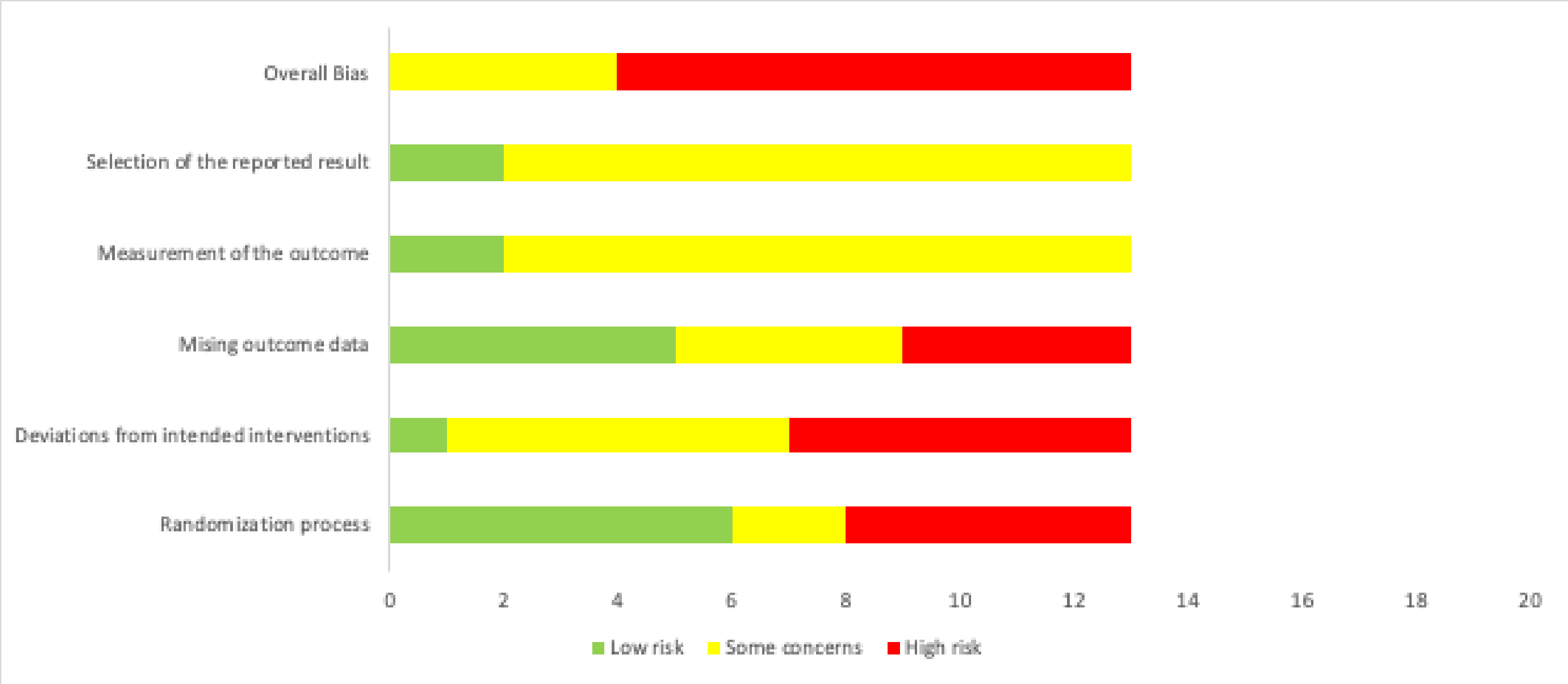
missing data													
3.3	PY	NA	PY	NA	PY	NA	PY	PY	NA	PY	PY	PY	PN
3.4	PY	NA	PN	NA	PY	NA	PN	PY	NA	PN	PY	PN	NA
ROB	H.R.	L.R.	S.C.	L.R.	H.R.	L.R.	S.C.	H.R.	L.R.	S.C.	H.R.	S.C.	L.R.
4.1 Inappropriate measures	N	N	PN	N	N	N	N	N	N	N	N	N	PN
4.2 Between groups differences	N	PN	N	PN	PN	N	PN	PN	PN	PN	PN	PN	PN
4.3 Assessor not blinded	Y	N	PY	Y	Y	Y	Y	PY	Y	PN	Y	Y	Y
4.4	PY	NA	PY	Y	PY	PY	PY	PY	PY	NA	PY	PY	PY
4.5	PN	NA	PN	PN	PN	PN	PN	PN	PN	NA	PN	PN	PN
ROB	S.C.	L.R.	S.C.	S.C.	S.C.	S.C.	S.C.	S.C.	S.C.	L.R.	S.C.	S.C.	S.C.
5.1 Data analysis pre-specified	NI	NI	NI	NI	NI	PY	PY	NI	NI	NI	N	NI	NI
5.2	NI	NI	NI	NI	NI	PN	PN	NI	NI	NI	PN	NI	NI
5.3	NI	NI	NI	NI	NI	N	N	NI	NI	NI	PN	NI	NI
ROB	S.C.	S.C.	S.C.	S.C.	S.C.	L.R.	L.R.	S.C.	S.C.	S.C.	S.C.	S.C.	S.C.
Overall R.O.B Judgement	High Risk	Some Concerns	High Risk	Some Concerns	High Risk	Some Concerns	High Risk	High Risk	Some Concerns	High Risk	High Risk	High Risk	High Risk

Y, yes; PY, probably yes; N, no; PN, probably no; NA, not applicable; NI, no information; ROB, risk of bias; H.R., high risk; S.C., some concerns; L.R., low risk

Sterne et al. (2019)

Figure 4

Graph showing distribution of risk of bias on the RoB2 across intervention studies



(a) Exercise based intervention

Three RCTs, with a total of 353 participants, investigated the effect of exercise based interventions. Two studies included FoF as a secondary outcome measure, while Van Ooijen et al. (2016) included reducing FoF as a main aim of their intervention. All three took place in the sub-acute setting (post hospital discharge). As described in Table 15, the frequency, duration and type of exercise varied between the studies. Their results are shown in Table 17. No study found a statistically significant improvement in FoF. One of these RCTs had three groups (Van Ooijen et al., 2016), an adaptability treadmill group, a conventional treadmill group and a usual therapy (control) group. They did not find any improvement in FoF between the two intervention groups either. Two of these studies had 'high risk of bias' and one had 'some concerns' on the RoB2.

Table 17

Results of exercise based intervention studies

Study	**FoF outcome measure used**	**Measurement time point**	**Statistically significant result? (Y/N) and p value (if given)**	**Result (mean $\pm$ SD) unless otherwise stated**	**Effect Size (Cohen's D)**	**Interpretation**
Beckmann (2021)	FES-I (lower score means lower FoF)	2 weeks	N	IG: 38.0 $\pm$ 12.8 CG: 38.6 $\pm$ 14.3	0.03	Negligible effect
		3 months	N	IG: 29.3 $\pm$ 11.5 CG: 31.6 $\pm$ 13.2	0.13	Negligible effect
Taraldsen (2019)	sFES-I (lower score means lower FoF)	2 months (adjusted for baseline)	N (p = 0.45)	Between group difference: mean = -0.2 (-1.3, 0.9 95% CI)	Unable to calculate	No significant difference in sFES-I scores between groups immediately post-intervention

		8 months (adjusted for baseline)	N (p = 0.95)	Between group difference: mean = 0.1 (-1.3, 1.3 95% CI)	Unable to calculate	No significant difference in sFES-I scores between groups at 8 months
Van Ooijen (2016)	FES-I (lower score means lower FoF)	Post-intervention	N (p = 0.21)	$n^2 = 0.057$	0.11	Negligible effect
		4 weeks	N (p = 0.68)	$n^2 = 0.016$	0.03	Negligible effect
		12 months	N (p = 0.50)	$n^2 = 0.045$	0.09	Negligible effect

FoF, fear of falling; Y, yes; N, no; SD, standard deviation; FES-I, falls efficacy scale international; IG, intervention group; CG, control group; sFES-I, short falls efficacy scale international; CI, confidence interval; n^2, partial eta squared effect size

(b) Psychological intervention

Only one study used solely a psychologically based intervention of motivational interviewing (MI) and measured FoF as a secondary outcome. This was delivered by trained physiotherapists in a 30-minute session per week, for 8 weeks. It did find a statistically significant improvement in FoF with a medium effect size as presented in Table 18. A MCID of 1.5 units has been estimated by Kwok and Pua (2016) for the mFES. The intervention group improved by 0.5 units (mean) ± 0.8 (SD) which is therefore not likely to be clinically relevant. This study had a 'high risk of bias' on the RoB2; one source of bias was the absence of an intention-to-treat analysis.

Table 18

Results of the psychological intervention study

Study	FoF outcome measure used	Measurement time point	Statistically significant result? (Y/N) and p value (if given)	Result (mean $\pm$ SD) unless otherwise stated	Effect Size (Cohen's D)	Interpretation
O'Halloran (2016)	mFES (higher score means higher confidence)	9 weeks (without adjusting for baseline)	Y	IG: 8.4 $\pm$ 2.1 CG: 6.7 $\pm$ 2.0	0.59	Medium effect, FoF score improved in IG more than the CG
		9 weeks (adjusted for baseline, week 9 minus week 0)	Y	IG: 0.5 $\pm$ 0.8 CG: -0.4 $\pm$ 1.0	0.70	Medium effect

FoF, fear of falling; Y, yes; N, no; SD, standard deviation; mFES, modified falls efficacy scale; IG, intervention group; CG, control group

(c) Multi-component (Combined exercise and psychological intervention)

Three studies (with a combined sample size of 296 participants) were included that utilised a combination of exercise based and psychological interventions, consisting of multiple components. For instance, the 'FIT-HIP' intervention (Scheffers-Barnhoorn et al., 2019) included components like CBT, guided exposure, MI, as well as physiotherapy sessions (see Table 15). Two of the three studies included FoF as a primary outcome measure. All were conducted in an in-patient setting and their control groups received usual rehabilitation care. Their results are provided in Table 19. Both Asplin et al. (2017) and Scheffers-Barnhoorn et al. (2019) had a 'high risk of bias' and both showed no statistically significant improvement in FoF scores post-intervention. Comparatively, Pfeiffer et al. (2020) had 'some concerns' identified on the RoB2. This study did find a statistically significant improvement in FoF measures at the final follow-up (1 month post-intervention) but not immediately post-intervention and the effect size was small or negligible (see Table 19). There is no data available on the MCID for the short FES-I and 'perceived ability to manage falls scale' measures used by this study. Overall, the effect of multi-component interventions on FoF was small or non-existent.

Table 19

Results of multi-component (combined exercise and psychologically based) intervention studies

Study	FoF outcome measure used	Measurement time point	Statistically significant result? (Y/N) and p value (if given)	Result (mean ± SD) unless otherwise stated	Effect Size (Cohen's D)	Interpretation
Asplin (2017)	FES Swedish (higher score means higher confidence)	Discharge	N (p = 0.83)	IG: median 73 (7 – 125 range) CG: median 73 (18-130 range)	-0.10	Negligible effect
		1 month	N (p = 0.98)	IG: median 89 (31 – 130 range) CG: median 90 (16 – 130 range)	0.09	Negligible effect
Pfeiffer (2020)	sFES-I (lower score means lower FoF)	Discharge at end of rehab	N (p = 0.18)	IG: 12.63 ± 4.14 CG: 12.50 ± 4.02	-0.02	Negligible effect
	PAMF (higher score means higher self-efficacy)	Discharge at end of rehab	N (p = 0.06)	IG: 12.80 ± 2.87 CG: 12.70 ± 2.29	0.03	Negligible effect
	sFES-I	3 months since discharge (1 month after intervention completed)	Y (p = 0.01)	IG: 11.40 ± 4.94 CG: 12.80 ± 4.66	0.21	Small, sFES-I scores improved more in the IG than the CG
	PAMF	3 months since discharge (1 month after intervention completed)	Y (p = 0.03)	IG: 13.30 ± 2.63 CG: 12.80 ± 2.43	0.14	PAMF scores improved more in the IG than the CG but negligible effect size
Scheffers-Barnhoorn (2019)	FES-I (lower score means lower FoF)	Discharge	N	IG: 32.8 ± 11.0 CG: 27.0 ± 8.2	-0.42	Small, At discharge the IG had more FoF than the CG

	3 month follow-up	N	IG: 35.1 ± 13.9 CG: 36.6 ± 12.4	0.08	Negligible, At 3 months, the IG had only slightly lower FoF than CG but not statistically significant
	6 month follow-up	N	IG: 36.5 ± 12.1 CG: 36.5 ± 11.9	0	None, At 6 months there was no difference in the FoF between the IG and CG

FoF, fear of falling; Y, yes; N, no; SD, standard deviation; FES, falls efficacy scale; IG, intervention group; CG, control group; sFES-I, short falls efficacy scale international; PAMF, perceived ability to manage falls scale; FES-I, falls efficacy scale international

(d) Accelerated or supported discharge

Three RCTs looked at accelerated or early supported discharge compared to usual rehabilitative care, with a total of 245 participants included across them (see Table 20). Two RCTs (Crotty et al., 2002; Ziden et al., 2008) had FoF as their primary measure and performed home based rehabilitation along with accelerated/ supported discharge; both reported a statistically significant improvement in FoF. The third RCT (Lockwood et al., 2019) included FoF as a secondary measure and provided a pre-discharge home visit as its main intervention (without any additional home based rehabilitation); this study did not show improvement in FoF. The effect size of the intervention in one study (Ziden et al., 2008, 2010) was large at 1 month, small (borderline medium) at 6 months and medium at 12 months post-intervention. However, unlike the remaining two studies which only had 'some concerns' on the RoB2, this study had 'high risk of bias' on the RoB2. The lack of allocation concealment and assessor blinding may have partially inflated their results. The study by Crotty et al. (2002) did not provide enough data to enable an effect size calculation and thus the magnitude of the effect is unknown. This study measured two FoF instruments; there was a statistically significant improvement on the FES score but not the ABC score (see Table 20). The clinical relevance of these results is difficult to determine as there is no data on the MCID for their respective instruments. Based on these results, accelerated/ supported discharge with a home based rehabilitation programme appears to have some positive effect on FoF, but the clinical importance of these findings is uncertain.

Table 20

Results of accelerated or supported discharge intervention studies

Study	FoF outcome measure used	Measurement time point	Statistically significant result? (Y/N) and p value (if given)	Result (mean ± SD) unless otherwise stated	Effect Size (Cohen's D)	Interpretation
Crotty 2002	FES (higher score means higher falls efficacy)	4 months	Y ($p < 0.05$)	IG: 90.5 median, 80.5 (25th percentile), 98.0 (75th percentile) CG: 79.5 median, 40.0 (25th percentile), 92.5 (75th percentile)	Unable to calculate from data provided	IG had a significant improvement in FoF scores compared to CG at 4 months
	ABC (higher score means higher balance confidence)	4 months	N	IG: 61.3 median, 45.5 (25th percentile), 75.2 (75th percentile) CG: 53.3 median, 26.8 (25th percentile), 74.6 (75th percentile)	Unable to calculate from data provided	IG had a slightly better ABC median score than CG at 4 months but not statistically significant
Lockwood 2019	FES-I (lower score means lower FoF)	30 days	N	IG: 35.1 ± 11.2 CG: 32.6 ± 13.6	-0.14	Negligible effect
		6 months	N	IG: 26.8 ± 8.0 CG: 28.0 ± 13.1	0.08	Negligible effect
Ziden 2008 and 2010	FES Swedish (higher score means higher	1 month	Y ($p < 0.0001$)	IG: 117.4 ± 12.0	0.97	Large, FOF scores improved in the IG significantly more than the

confidence)			CG: 85.5 ± 30.5		CG at 1 month
	6 months	Y (p < 0.001)	IG: 128 median, 20 (min), 160 (max) CG: 105 median, 7 (min), 130 (max)	0.48	Small, FOF scores improved in the IG significantly more than the CG at 6 months
	12 months	Y (p < 0.001)	IG: 128 median, 61 (min), 130 (max) CG: 102 median, 13 (min), 130 (max)	0.73	Medium, FOF scores improved in the IG significantly more than the CG at 12 months

FoF, fear of falling; Y, yes; N, no; SD, standard deviation; FES, falls efficacy scale; IG, intervention group; CG, control group; ABC, activities-specific balance confidence scale; FES-I, falls efficacy scale international

(e) Other

Lastly, three studies included in our review utilised interventions that did not fit within the preceding categories, so were categorised as ‘other’ (see Table 21). FoF was a secondary measure in all three studies. The RCT by Birks et al. (2003) assessed the use of hip protectors. They did not report the statistical significance of their result but the effect size was negligible. One study (Ko et al., 2019) was a pre-test post-test design study investigating a transition care programme (a nurse led individualised programme consisting of education such as fall prevention, and emotional support to minimise functional decline). They did report a statistically significant improvement in the intervention group compared to the control but the effect size was small. Peichl et al. (2005) investigated the effect of a salmon calcitonin spray (administered for one year) on bone density and fracture rate and reported a statistically significant result for FoF improvement with a medium effect size. However, all three studies had methodological flaws and were considered ‘high risk of bias’ on the RoB2.

Table 21

Results of 'other' intervention studies

Study	FoF outcome measure used	Measurement time point	Statistically significant result? (Y/N) and p value (if given)	Result (mean ± SD) unless otherwise stated	Effect Size (Cohen's D)	Interpretation
Birks (2003)	FoF 6 point Likert scale (0 = not worried, 5 = very worried)	6 weeks	Not stated	IG: 1.73 ± 1.83 CG: 1.75 ± 1.91	0.01	Negligible difference between groups on FoF scores at 6 weeks
		6 months	Not stated	IG: 2.59 ± 1.54 CG: 2.78 ± 1.64	0.08	Negligible difference between groups on FoF scores at 6 months
Ko 2019	FES Tinetti 10 item (lower score means lower FoF)	1-2 days before discharge, pre-test post-test design	Y ($p < 0.01$)	IG: 23.83 ± 29.35 CG: 36.19 ± 26.86	0.31	Small, FoF scores improved in the IG more than the CG
Peichl (2005)	FES Tinetti 14 item (higher score means lesser FoF)	12 months	Y ($p = 0.005$)	IG: 3.28 ± 1.24 CG: 2.29 ± 1.08	0.60	Medium, FES scores improved in the IG more than the CG

FoF, fear of falling; Y, yes; N, no; SD, standard deviation; IG, intervention group; CG, control group; FES, falls efficacy scale

CHAPTER 4 DISCUSSION

This systematic review set out to synthesize existing literature on FoF after hip fracture in relation to four important research questions: 'what is the prevalence of FoF in hip fracture patients?', 'what are the psychometric properties of instruments used to measure FoF in hip fracture patients?', 'what measures of physical function or performance is FoF associated with in hip fracture patients?' and 'which interventions are effective in reducing FoF after hip fracture?'. The main findings of this review are that FoF is highly prevalent but decreases with time post-fracture; the FES-I and FFQ-R are two reliable and valid instruments for measuring FoF in hip fracture patients, and FoF consistently correlates with measures of physical function or performance in hip fracture patients. However, this review also found that currently there is insufficient evidence to support any intervention to reduce FoF after hip fracture. Thus, this review contributes to the existing database on FoF after hip fracture by synthesizing the literature, making recommendations for clinical practice and guiding future research. The main results for each question are discussed below.

4.1 Prevalence

Our systematic review found that FoF prevalence ranged between 50 to 100% at 1-4 weeks, 47 to 59% at around 12 weeks and 23 to 50% for the period 12-58 weeks post hip fracture. Thus, FoF is extremely common, especially early after hip fracture. FoF prevalence after hip fracture has not been evaluated in any review previously; the systematic review by Visschedijk et al. (2010) did not find any studies that adequately reported this. Thus, this is the first systematic review to report FoF prevalence estimates after hip fracture. The overall post-fracture FoF prevalence range of 23% to 100% from our study is slightly higher than the 21 % to 85% range reported in community-dwelling older adults (Scheffer et al., 2008) but is closer to the 29% to 92% (Jorstad et al., 2005) reported for older adults who have sustained a fall. FoF rates have previously been found to be higher in frail elderly, those with heightened falls risk and those at increased risk of sustaining a hip fracture as well as those with previous fall-related fractures (Schoene et al., 2019). This may explain the similarity between the prevalence ranges of our hip fracture patients with that of elderly fallers. The highest prevalence found in our review was 100% which was seen in the first week after hip fracture. This value was obtained from a single study that used a SIQ with yes/ no responses to measure FoF rates. While such a high value can be expected in patients that have just sustained a fall bearing the serious consequence of a hip fracture, further studies are needed to validate this finding.

Our findings show a trend of decreasing FoF prevalence as time passes since hip fracture. In other words, FoF appears to be higher immediately after hip fracture and gradually decreases as time goes on. Intuitively, this makes sense because it can be expected that an individual's FoF would improve as they make progress with their mobility in the later stages of their rehabilitation. It would be interesting to further explore this relationship in future studies by comparing FoF over time during hip fracture rehabilitation with physical/ functional progress over the same time period.

There were some sources of bias in the reviewed studies which may influence the reliability of their results. Studies measuring prevalence must ensure that the target population is well represented (Hoy et al., 2012). However, the sampling methods of included studies were inadequate, relying on convenience samples only. For hip fracture patients, gathering data from a national registry would have reduced this source of bias. Also, most studies used a SIQ to measure FoF prevalence. The reliability and validity of such an approach has yet to be determined (Jorstad et al., 2005). That said, a similar approach has been used in studies assessing FoF epidemiology in other populations (Greenberg, 2012; Lach, 2005).

4.2 Instrument psychometrics

A previous systematic review (Visschedijk et al., 2010) did not find any studies that had assessed the psychometric properties of FoF measurement tools specifically in hip fracture patients. Our review found that the psychometric properties of two FoF instruments have been measured in hip fracture patients: the FES-I and the FFQ-R.

The FES-I is an internally consistent, reliable and uni-dimensional instrument with no floor and ceiling effects. Thus, it is a suitable tool for measuring FoF after hip fracture, though, it is important to note that it was found to relate more closely to measures of physical function than the psychological construct of fear. Also, the measurement error (SEM and SDC) for the FES-I was high in this study, which could limit its ability to accurately measure change in FoF in hip fracture patients.

The psychometric properties of the FES-I are similar in other patient groups. It has excellent internal consistency and reliability in community-dwelling older adults (Yardley et al., 2005) and in geriatric patients with or without cognitive impairment (Hauer et al., 2010). The FES-I had strong internal validity in a study on older adults, confirming that it is a uni-dimensional tool assessing a single construct (Delbaere et al., 2010). Moreover, a systematic review concluded that the FES-I is valid, reliable and comparable across older adults of different cultural backgrounds and is therefore recommended for use both clinically and in research (Marques-Vieira et al., 2016). The FES-I can also be used in fall prevention programmes (Marques-Vieira et al., 2016), with cut-off scores that have been recommended to indicate whether there is a low, moderate or high concern for falling (Delbaere et al., 2010).

Both the 15-item and 6-item versions of FFQ-R were also found to be internally consistent and reliable in the hip fracture patient group. The construct validity of the 15 and 6-item versions of FFQ-R were very similar; showing convergence with the short FES-I and divergence from measures of depression and negative affect. These findings are consistent with that for the original FFQ which also had acceptable reliability, correlated with the FES, and correlated with the same factors (including fear) as the 15-item FFQ-R as part of factor analysis (Dayhoff et al., 1994). One advantage of the FFQ-R is that it was revised specifically for the hip fracture patient group and measures fear more globally instead of measuring self-efficacy during specific functional tasks (Bower et al., 2016).

Overall the studies reviewing psychometric properties were fairly well conducted with minor sources of bias. Thus, from our review, the evidence indicates that the FES-I and FFQ-R are suitable to use with hip fracture patients to measure the constructs of falls efficacy and fear related to falling, respectively. However, further studies are needed to determine whether these tools can accurately measure change in FoF in a hip fracture population.

4.3 Associations with measures of physical function or performance

The findings from cross-sectional studies show that FoF is consistently associated with measures of physical function or performance. The correlations with balance, gait speed and composite physical performance measures were consistent with mostly medium to large correlation coefficients, demonstrating that higher FoF was linked to poorer performance on these measures. These associations were consistently demonstrated across studies, despite differences in methodologies or outcome measures used. Likewise, our study found FoF to correlate with self-reported function (or a person's self-perceived functional ability). An association with physical activity (step count) and muscle strength was also shown but needs to be confirmed by more studies. It must be noted, that most studies used measures related to 'falls efficacy' or 'balance confidence' constructs (e.g. the FES-I or ABC); very few used measures that focused more on the construct of 'fear'. It is possible that the associations seen in these studies may not have been as strong if 'fear' related measures were used.

The time since hip fracture in these cross-sectional studies ranged from the acute post-operative period of within 5 – 8 days (Kronborg et al., 2016) to over a year (Edgren et al., 2013; Portegijs et al., 2012), but a significant correlation was commonly observed across time frames. Thus, FoF appears to correlate with physical function in the early stages of rehabilitation through to a year later. There are a number of possible explanations for this association. One theory may be the fear avoidance cycle; those with FoF tend to avoid or reduce participation in activities in which they are concerned about falling which in turn can contribute to a decline in physical function. Thus, FoF may lead to poorer physical function. On the other hand, physical function may be poor after sustaining a hip fracture and those patients could consequently develop a rational 'fear' of falling in light of their poor physical ability. Alternatively, this association may be mediated by other underlying variables such as age, falls history, depression, pre-fracture living situation or health status (which are known risk factors for FoF). Most studies did not control for such confounding variables which is a limitation and source of bias in these studies. When multivariate analysis was utilised, the strength of the relationship between FoF and measures of physical function was sometimes reduced, suggesting that confounding factors should be measured and taken into account in future studies. In summary, while it is difficult to establish a causal relationship between FoF and physical function variables from cross-sectional studies, it is clear that these two variables are highly correlated (the few prospective studies will be discussed below). Thus, FoF appears to be an important factor after hip fracture and may be relevant for hip fracture recovery.

Our findings align with that of several studies in older adults without a history of hip fracture. FoF is strongly associated with balance and gait problems in older adults (Austin et al., 2007; Hoang et al., 2017; Rochat et al., 2010; Scheffer et al., 2008; Schepens et al., 2012). FoF is also linked to poorer physical activity (Akosile et al., 2021; Jefferis et al., 2014; Scheffer et al., 2008), physical function (Choi et al., 2017; Cumming et al., 2000; Hoang et al., 2017; Park et al., 2014; Scheffer et al., 2008), and self-perceived health (da Cruz et al., 2017; Hoang et al., 2017). In fact, all FoF-related constructs were robustly associated with physical function in a systematic review (Denkinger et al., 2015) which shows the relevance of FoF for older adults. This is further supported by literature on its wider associations with other important variables in older adults. FoF has been consistently linked to activity restriction (Deshpande et al., 2008) as well as falls (Lavedan et al., 2018). It is also associated with other psychological factors including depression and anxiety (Gagnon et al., 2005; Painter et al., 2012), and can impact on QoL (Hughes et al., 2015; Schoene et al., 2019).

Finally, the ability of FoF to prospectively predict measures of physical function several months later was less clear and remains uncertain. There were only three prospective studies reporting on FoF associations; these showed mixed results. As each study measured different physical function variables, their results cannot be easily combined. Most often, FoF did not predict performance on physical function measures at follow-up, after controlling for covariates. When FoF was found to predict physical function the effect size was small. In the large prospective study by Oude Voshaar et al. (2006), baseline FoF tended not to predict physical functional performance at 6 months whereas FoF at 6 weeks tended to be able to do so. This suggests that the relationship between FoF and physical function may be stronger when they are measured at a closer timeframe to each other. Alternatively, it can be expected to have FoF immediately after hip fracture, but having persistent FoF at 6 weeks might be more of a risk factor for poor functional recovery. However, these findings need to be replicated in further studies before any firm deductions can be made.

Studies in older adults (not specifically hip fracture) have shown that FoF can predict variables of physical function. FoF predicts limitations in mobility and daily activities (M. Liu et al., 2021) as well as functional disability (Auais et al., 2018). Additionally, prospective studies in older adults have shown that baseline FoF is predictive of future falls and equally falls at baseline are predictive of developing FoF (Friedman et al., 2002; Lavedan et al., 2018). Thus, the association between FoF and falls is consistent but there is ongoing debate about which comes first (Evitt & Quigley, 2004; Lavedan et al., 2018). Similarly, one could argue about the relationship between FoF after hip fracture and poorer physical function. While it is clear from cross-sectional studies in our review that these two variables are consistently correlated, further prospective studies examining the nature of this association over a longer follow-up period are required to see how this relationship changes as time lapses after hip fracture surgery. This will be valuable in determining whether FoF predicts later physical function and vice versa in hip fracture patients.

4.4 Interventions

The three studies investigating exercise based interventions (consisting of an exercise programme or exercise sessions and a treadmill training intervention) did not improve FoF in hip fracture patients. In contrast, a Cochrane review (Kumar et al., 2016) found that there was a small to moderate reduction in FoF of community-dwelling older adults from exercise based interventions, regardless of the type and dosage of exercise. However, this was low quality evidence and the effects of exercise did not appear to last beyond the intervention. The interventions studied in the 30 trials in their review included balance, strength and resistance training, tai chi, and yoga while the controls only included usual care or education (with any studies using an exercise based intervention in the control group excluded). In comparison, the control groups in our review received usual care and physiotherapy, which typically included some exercise. This is because hip fracture patients in the control group cannot be ethically denied usual care after major fracture and subsequent surgical repair. Therefore, the dose of exercise provided to the intervention group may not have been sufficiently different to the control group to clearly affect outcomes, including FoF. This may be why an improvement in FoF was seen in community-dwelling older adults following exercise based interventions (Kumar et al., 2016), but not in our review. Alternatively, the severity of FoF in our group of hip fracture patients receiving rehabilitation may have been greater than that in community-dwelling older adults, making it more difficult to change.

The intervention of 'tai chi' has been found to have a medium effect on improving balance confidence in older adults in a systematic review (Rand et al., 2011). These findings are validated by a recent RCT that also showed a positive effect on FoF from tai chi (Hosseini et al., 2018). Tai chi may not only improve balance (and consequently balance confidence) but may also address the cognitive and emotional aspects of the individual by promoting relaxation and increased awareness which may in turn improve balance confidence (Rand et al., 2011). Tai chi has also been found to play a role in fall and fracture prevention (Chow et al., 2018; Hu et al., 2016; Wayne et al., 2012). None of the studies in our review included 'tai chi' as an intervention, therefore, its effect on FoF post hip fracture is not known. While it may be physically difficult for patients to perform tai chi in the acute stages after hip fracture due to pain and difficulty weight-bearing, given the results described above, future studies may wish to investigate the utility of tai chi in the later stages of hip fracture rehabilitation.

Multi-component interventions that combined exercise with psychological interventions (e.g. CBT) also did not show any effect in reducing FoF after hip fracture. Theoretically, a combination of physical and psychological measures should improve FoF; the physical component helps improve falls efficacy/ balance confidence by improving strength and balance, while the psychological component empowers the patient to overcome their fear (Ganji, 2018). Similar multi-component interventions have shown success in reducing FoF (Whipple et al., 2018; Zijlstra et al., 2007) and improving balance confidence (Bula et al., 2011), in community-dwelling older adults. An important difference could be the setting where these interventions took place. All three studies in our review took place in in-patient rehabilitation settings and the control group received usual care, consisting of inter-disciplinary rehabilitation. In this context, it may be difficult for these trials to show a significant improvement in these early stages of hip fracture rehabilitation compared to the improvements seen in community-dwelling older adults. Also, as demonstrated in Figure 3, FoF is more prevalent in the early stages after hip fracture but decreases over time. Thus, it may make it difficult to see a difference between the intervention and control groups if both groups experience a natural reduction in FoF anyway (as part of natural history). Bower et al. (2016) make a similar point, suggesting that high FoF early after hip fracture could be transient and adaptive, but persistent high FoF three months post-fracture could be maladaptive and warrants intervention. Therefore, interventions may show a stronger effect on FoF in patients that continue to have residual FoF later on (such as 6-12 weeks post-fracture) compared to early post-fracture.

Additionally, CBT has been effective in reducing FoF in community-dwelling older adults, on its own (Dorresteijn et al., 2016; T. Liu et al., 2018), or as part of multi-component interventions (Chua et al., 2019). CBT utilises cognitive restructuring and behaviour change techniques to address self-efficacy and beliefs about falling (T. Liu et al., 2018; Scheffers-Barnhoorn et al., 2019). CBT was included as a psychological component in some of the multi-component studies in our review which mostly showed no/ minimal improvement in FoF. However, no studies investigated solely CBT as an intervention, and further research is needed to establish its effect on FoF after hip fracture.

Accelerated or supported discharge based interventions showed mixed results. These interventions involved home visit(s) including home modifications, advice and education. The study with only home visits as the main intervention did not show any effect on FoF, whereas two studies that added a goal-oriented and tailored home rehabilitation programme provided by therapists (compared to routine community follow-up for control groups) did show some improvement in FoF compared to the control group. However, the effect size varied and the results of one study in particular were biased by methodological flaws; including a lack of assessor blinding and allocation concealment that may have resulted in an inflation of the effect in favour of the intervention group (Ziden et al., 2010). A recent meta-analysis (Sheehan et al., 2021) looked at the effect of community-based outdoor mobility interventions on falls efficacy after hip fracture and had a similar finding to our review. They reviewed three RCTs and reported a small increase in falls efficacy; however, upon removing the findings of Ziden et al. (2010) due to heterogeneity, they reported that outdoor mobility interventions did not make a difference to falls efficacy. On the other hand, in community-dwelling older adults (Zijlstra et al., 2007) and in some neurological conditions (Abou et al., 2021), home based exercise interventions have shown some success in reducing FoF. It may be that undertaking exercise in their own home setting is more meaningful for patients and enables better enhancement of their falls efficacy, with greater carryover to the performance of activities of daily living.

The only intervention to show a significant improvement with a medium effect size was MI, which is a psychologically based intervention involving a directive style of communication consisting of techniques used to address beliefs (e.g. about low confidence and FoF), or ambivalence about change, e.g. in physical activity (O'Halloran et al., 2016). MI is being increasingly researched as a behaviour change intervention to increase physical activity, self-efficacy of engaging in activity, as well as fall prevention in older adults, with mixed results (Arkkukangas & Hultgren, 2019; Johnson et al., 2021; Larsen et al., 2021). While MI may be a promising intervention, it must be noted that our finding is from a single study (O'Halloran et al., 2016) and this study had some methodological concerns and a small sample size. Additionally, the improvement did not reach the estimated MCID for the mFES so is unlikely to be clinically important. MI was also one of the components of the multi-component intervention in the study by Scheffers-Barnhoorn et al. (2019) which did not find any improvements in FoF. Overall, a firm conclusion on the effectiveness of MI in addressing FoF in hip fracture patients is yet to be established.

The findings from single studies on hip protectors (Birks et al., 2003), a salmon calcitonin nasal spray (Peichl et al., 2005), and a unique transition theory based intervention involving education (Ko et al., 2019) were flawed by significant methodological issues and were not substantive enough to draw conclusions about their effectiveness in improving FoF. The use of these interventions needs to be supported by further robust research to be of any consideration in clinical use.

Interestingly, no study specifically investigated the intervention of graded exposure therapy. Graded exposure is a common and effective treatment strategy for anxiety disorders as well as pain-related fear and anxiety (Bailey et al., 2010; Simons et al., 2020; Vlaeyen et al., 2002). It has also been used by physiotherapists to address fear avoidance behaviours seen in low back pain patients, with some success (George et al., 2010; Lopez et al., 2016; Macedo et al., 2010). It involves the patient being confronted with their fear in a progressive and hierarchical manner (Furnham et al., 2013; Vlaeyen et al., 2002) and is based on the theoretical principles of habituation and systematic desensitisation (Vinograd & Craske, 2020). In light of the fear avoidance behaviours linked to FoF, this intervention has the potential to be similarly effective in addressing FoF after hip fracture. In the FoF context, this could be implemented by graded exposure to the feared activity or task. This may also explain why the studies using 'home-based exercise with accelerated discharge' in our review showed more promising results. During the course of such home based programmes, hip fracture patients may have been exposed to functional tasks that were being avoided. Graded exposure could be utilised in clinical settings by psychologists and/or physiotherapists, however, some training or upskilling may be required (Macedo et al., 2010; Simons et al., 2020). Given its success in treating other anxiety and fear based disorders, including fear of movement, we recommend that this intervention receives more attention and further investigation in the hip fracture population.

In summary, the literature on interventions targeting FoF after hip fracture has grown since the previous systematic review by Visschedijk et al. (2010), which only found 4 intervention studies addressing FoF. However, based on the findings of our review, there is still insufficient evidence to strongly support any interventions to reduce FoF after hip fracture. A large majority of the studies in our review did not find improvements in FoF as an outcome of their chosen interventions. However, most studies only included FoF as a secondary measure. These studies could be underpowered as their sample size was not calculated based on FoF as the primary outcome measure. Additionally, many of the included studies were considered 'high risk of bias' with methodological flaws.

4.5 Limitations of the existing research on FoF after hip fracture

The studies included in this systematic review had a number of methodological limitations which were outlined specifically in their risk of bias assessments, but as a whole there were some noteworthy quality issues. Firstly, many studies had selection bias as they excluded participants with cognitive impairment, pre-fracture mobility issues or major co-morbidities. Thus, the findings from this review may not be generalisable to all hip fracture patients. Also, FoF may be a greater issue in cognitively impaired patients (Peeters et al., 2020), which has not been studied well in the current literature. Secondly, female participants made up a resounding majority in all studies included in this review. While hip fracture does occur in females more than males (66-69% females had a hip fracture in the latest Australian and New Zealand Hip Fracture Registry (2021) report), the average across all studies included in our review was higher at 78%, with some studies including 100% females. It could be that more females consented to participate which may be a potential source of bias in these studies and affects the generalisation of findings to males. Thirdly, many studies did not clearly report the time since hip fracture. This makes it difficult to appropriately interpret and draw implications from their results as we cannot link their findings adequately to the participants' stage of rehabilitation. Lastly, there may still be a lack of clarity about the fall-related psychological construct being measured as studies may be aiming to measure one construct (e.g. FoF) but may use an instrument that is actually measuring a related bur arguably different construct, like falls efficacy. This will be discussed further in Chapter 6 for future recommendations.

4.6 Strengths and limitations of our review

This systematic review was undertaken in alignment with PRISMA guidelines which helped minimize bias and optimize the methodological quality of this study. The study protocol was pre-registered on PROSPERO to ensure that the researchers aligned with the set protocol throughout the course of the study, to minimize reporting bias. We only made a minor deviation from our protocol; we added the exclusion criteria for pilot or feasibility studies for research question four.

Two reviewers independently performed the database search, study screening, and selection. This helped ensure that our data gathering processes were robust and minimised error. We did not set any limits to the years of publications; this allowed us to obtain a comprehensive review of the existing literature in this field. The oldest study included was from 1986 and the most recent was published in early 2021. We also used forward and backward citation searches to ensure we captured all the relevant peer-reviewed literature. The reviewers were not blind to the names of the authors of included studies; however, there is no known bias from this as there are no affiliations or conflicts of interest.

Two independent reviewers undertook data extraction separately to ensure greater accuracy. Detailed data analysis was undertaken alongside discussion between the researchers to ensure unbiased and streamlined interpretation of the results. Thorough and critical quality appraisal was completed using contemporary and stringent appraisal tools that have been developed by experts. The AXIS tool was the only tool that did not fully meet the requirements for our review, we therefore modified it to incorporate appraisal of important sources of bias such as confounding variables and loss to follow-up. Lastly, as undertaking a meta-analysis was outside the scope of this dissertation; we did not formally measure and cannot account for any potential publication bias.

CHAPTER 5 IMPLICATIONS FOR CLINICAL PRACTICE

Our findings confirm that FoF is prevalent after hip fracture and is particularly common in the first four weeks after fracture. Thus, clinicians should be aware of FoF in hip fracture patients during their early rehabilitation phase and consider assessing it. Importantly, FoF could vary from person to person and in addition to asking patients whether or not they fear falling, it may be important to individually assess how this impacts their rehabilitation. This may be done by having an open conversation to obtain the patient's perspectives (Evitt & Quigley, 2004). However, we recommend that this is complemented with a validated measure such as the FES-I which will provide useful information about which particular activities or tasks the patient fears falling in the most. This can be used to tailor therapy sessions to address FoF during those specific tasks. Thus, administering the FES-I may be most beneficial to physiotherapists and occupational therapists involved in the physical and functional rehabilitation of these patients.

FoF may be labile (unstable) during the rehabilitation period and some studies have suggested that it should be re-measured over time (Lach, 2005; Visschedijk et al., 2010). Our findings confirm that FoF does change over time after hip fracture. Thus, clinicians could not only measure FoF at the start of the patient's hip fracture rehabilitation journey (to screen for the presence and severity of FoF) but also re-assess it at relevant time-points, for instance, during the sub-acute rehabilitation stage, after a period of intervention, and at discharge from in-patient rehabilitation prior to transition back into the community. Given that FoF is common in the first four weeks after hip fracture and may naturally decrease over time, it may be relevant to assess for persistent FoF 6-12 weeks post-fracture, as this may be both more clinically important, and amenable to intervention. It may also be useful to categorise patients as having high vs low FoF in clinical practice, for instance by utilising a cut-off point on the FES-I for older adults as suggested by Delbaere et al. (2010). This can potentially help therapists categorise those patients that are most in need for intervention and therefore more likely to benefit from their time and input in targeting FoF.

Based on our findings, the FES-I and FFQ-R are suitable and recommended for use after hip fracture. Clinicians must however be aware of what specific construct the chosen instrument is measuring. In other words, it is important for therapists to understand the underlying construct that they want to measure so they can select the appropriate tool. In hip fracture patients, the FES-I focuses on falls efficacy and relates more to constructs of physical and functional performance than fear. In contrast, the FFQ-R may be more suitable to measure the construct of ‘fear’ related to falling. Additionally, the shorter 6-item FFQ-R may be more clinically useful as a measure of the construct of fear in comparison to a simple yes/no SIQ due to its brevity, established psychometric properties in hip fracture patients, as well as its ability to assess the degree of fear (Bower et al., 2015).

It must be noted that these FoF instruments are self-report measures which can be given to the patient to complete independently or can be administered by a clinician in the form of an interview. They do, however, require a level of understanding from the patient to be able to adequately answer the questions. Thus, they may be more suitable to use with patients that have reasonable cognitive and communication skills. In fact, the psychometric studies in our review were completed in patients without cognitive impairment or communication difficulties. It is useful for health professionals to understand this when administering these tools to their patients.

We cannot draw causal relationships from associations observed in cross-sectional studies; however, the consistent and moderately strong link between FoF and physical function seen in our review highlights the potential importance of FoF on functional recovery after hip fracture. It implies that hip fracture patients with higher FoF may have worse physical and functional outcomes in their rehabilitation, although more longitudinal and/or controlled trials are needed to confirm this. These findings are useful for clinicians as they support the argument for assessing and addressing FoF during hip fracture rehabilitation to optimise recovery of gait, balance and other physical function variables. An established theoretical model, such as the fear avoidance cycle, further strengthens this argument. We recommend that health professionals consider FoF as a potential influential factor in their patient’s rehabilitation and suspect FoF as one of the risk factors in patients with poor mobility and functional recovery. Thus, therapists could clinically reason to include FoF in their problem list of factors that need to be addressed to optimise their patients hip fracture rehabilitation.

Based on our review findings, we cannot recommend any particular intervention to specifically target FoF in the hip fracture population. Home based exercise with accelerated/ supported discharge as well as MI have shown some potential but it is still too early to make a clinical judgement about their effectiveness from the limited and low quality evidence in the existing literature. There is a need for further trials to guide clinical practice. In the meantime, therapists still need to be aware and mindful of FoF and its potential impact on the patient’s progress during physical rehabilitation and consider strategies to address FoF, depending on individual patient needs.

Given the prevalence and relevance of FoF after hip fracture, we recommend that it should be included in the data collection in national hip fracture registries.

CHAPTER 6 RECOMMENDATIONS FOR FUTURE RESEARCH

Our findings show that the growing body of literature has addressed some of the gaps identified by the previous systematic review (Visschedijk et al., 2010), however, there are some ongoing areas that remain unmet. Our findings also pave the way for future research.

Knowledge about FoF prevalence after hip fracture has grown. There is now a need for more studies to add to and consolidate the evidence base about FoF prevalence in the very early days after hip fracture. Likewise, future prospective studies need to evaluate FoF prevalence over a longer follow-up period (of 1 year and more) in the same participants to investigate how FoF changes as time lapses well beyond the acute hip fracture stage. This will help understand whether FoF continues to be an issue once patients have transitioned back into the community. We recommend that future studies use more representative populations (e.g. based on national hip fracture registries) and validated and reliable tools such as the FES-I to measure FoF prevalence rather than a SIQ which has limited psychometric properties.

The heterogeneity of design and methodologies of the studies included in this review made it difficult to compare and combine their findings. The debate over the different constructs (FoF, falls efficacy and balance confidence), terminology used, as well as availability of numerous measurement instruments could be a part of the reason for this. It is important to have a clearer understanding and definition of these constructs to ensure appropriate measurement and interpretation of findings in research (Adamczewska & Nyman, 2018). There is a call for researchers to make a concerted effort to reach a consensus about FoF measurement and be explicit about which construct they are measuring (Kumar et al., 2016; Perez-Jara et al., 2010).

It may be useful to add to the evidence base on the psychometric properties of instruments for each fall-related psychological construct (FoF, falls efficacy and balance confidence), although falls efficacy and balance confidence are highly similar. Studies are needed to investigate the tools used commonly (both clinically and in research) such as the ABC, short FES-I, and Survey of Activities and Fear of Falling in the Elderly (SAFE), specifically in the hip fracture patient population, to test their suitability for this population. In community-dwelling older adults, these tools have been psychometrically tested and are shown to be valid and/ or reliable (Kempen et al., 2008; Lachman et al., 1998; Powell & Myers, 1995). Some of these tools have distinct advantages. For example, taking less time to complete, the short FES-I may be more practical for clinical use (Kempen et al., 2008) and the SAFE may help differentiate ‘FoF leading to activity restriction’ from ‘FoF during activities’ (Greenberg, 2012; Lachman et al., 1998). It would also be useful for studies to investigate the MCID and SDC for these measures.

There is already a significant body of research that has investigated the association between FoF and measures of physical function and performance, as identified in our review. However, most of the studies were cross-sectional in nature. Thus, prospective studies with longer follow-up periods are required to see how the relationship of FoF in comparison to other variables (e.g. gait, balance, and function) changes over time after hip fracture. Additionally, an important limitation of the current literature is the lack of controlling for confounding variables such as history of falls and pre-fracture mobility. This will need to be addressed in future studies. Prospective studies also need to further test the ability of FoF to predict physical function outcomes (and vice versa) in hip fracture patients.

The existing literature base is lacking strong evidence in support of interventions that are effective in reducing FoF after hip fracture. Home based exercises with accelerated/ supported discharge as well as the ‘behaviour change’ intervention of MI look promising but further large-scale studies are needed to support the use of these interventions. Many studies only included FoF as a secondary outcome measure with few aiming to specifically reduce FoF. Previous systematic reviews on FoF in older adults have also found this (Kumar et al., 2016; Zijlstra et al., 2007). Future studies need to investigate targeted and theoretically-based interventions designed for addressing FoF after hip fracture. As discussed in the section above, we recommend that the intervention of ‘graded exposure’ to fearful activities as well as CBT should be investigated in this patient group. Also, ‘tai chi’ may be another intervention worth investigating in hip fracture patients, particularly in later/ post-acute stages of rehabilitation as it has shown benefit in reducing FoF in the community-dwelling older adult group. There are also features of the study design that could be improved for future clinical trials, including longer follow-up periods, sample sizes that are sufficient to observe a MCID in FoF, robust randomisation and allocation concealment procedures as well as improved strategies to minimise loss to follow-up.

Furthermore, future studies need to add to the evidence base by investigating FoF in hip fracture patients with some cognitive impairment as well as other co-morbidities. The existing literature has commonly excluded these patients probably due to the difficulty of conducting research on such patients. However, given that cognitive impairment and co-morbidities are extremely common in hip fracture patients (ANZHFR, 2019) it is imperative for researchers to make an effort to target this group to make their research more clinically useful.

Conclusion

In this systematic review, the existing literature on FoF after hip fracture in relation to four research questions was thoroughly searched, critically appraised for methodological quality, and the findings were systematically reviewed. The findings from this review demonstrate that FoF is prevalent after hip fracture and is consistently associated with poorer physical function and performance. This is the first systematic review to report FoF prevalence after hip fracture and to identify the trend that FoF appears to decrease as time passes post-fracture. Only two measurement instruments have been reviewed in hip fracture patients; current evidence demonstrates that the FES-I and FFQ-R are reliable and valid measures of FoF with a greater focus on falls efficacy and fear, respectively. Other commonly used instruments such as the short FES-I and ABC still need to be assessed in this population. Currently, the literature does not definitively support any intervention to combat FoF in a hip fracture population, with important methodological limitations in many of the studies reviewed. There is a strong need for more robust and larger RCTs that investigate targeted interventions with a sound theoretical base (for example, interventions designed with models of fear in mind, such as graded exposure and CBT), in acute rehabilitation as well as community settings, to guide future clinical practice.

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Appendices

Appendix A

Search Strategy

EBSCO Health Databases

#1 (hip OR “neck of femur” OR “proximal femur” OR nof OR inter-trochanter* OR intertrochanter* OR “inter trochanter*” OR sub-trochanter* OR subtrochanter* OR “sub trochanter*”) n3 (fracture*)

#2 (fear* OR self-efficacy OR “self efficacy” OR confidence OR falls-efficacy OR “falls efficacy”) n5 (fall OR falls OR falling OR balance)

#3 Combine #1 AND #2

Scopus

#1 (hip OR “neck of femur” OR “proximal femur” OR nof OR inter-trochanter* OR intertrochanter* OR “inter trochanter*” OR sub-trochanter* OR subtrochanter* OR “sub trochanter*”) W3 (fracture*)

#2 (fear* OR self-efficacy OR “self efficacy” OR confidence OR falls-efficacy OR “falls efficacy”) W5 (fall OR falls OR falling OR balance)

#3 Combine #1 AND #2

PsychINFO

#1 (hip OR “neck of femur” OR “proximal femur” OR nof OR inter-trochanter* OR intertrochanter* OR “inter trochanter*” OR sub-trochanter* OR subtrochanter* OR “sub trochanter*”) adj3 (fracture*)

#2 (fear* OR self-efficacy OR “self efficacy” OR confidence OR falls-efficacy OR “falls efficacy”) adj5 (fall OR falls OR falling OR balance)

#3 Combine #1 AND #2

Appendix B

Modified AXIS Tool

(Downes et al., 2016; NIH, 2021)

Introduction

1 Were the aims/objectives of the study clear?

Methods

2 Was the study design appropriate for the stated aim(s)?

3 Was the sample size justified?

4 Was the target/reference population clearly defined? (Is it clear who the research was about?)

5 Was the sample frame taken from an appropriate population base so that it closely represented the target/reference population under investigation?

6 Was the selection process likely to select subjects/participants that were representative of the target/reference population under investigation?

7 Were measures undertaken to address and categorise non-responders?

8 Were the risk factor and outcome variables measured appropriate to the aims of the study?

9 Were the risk factor and outcome variables measured correctly using instruments/measurements that had been trialled, piloted or published previously?

10 Is it clear what was used to determined statistical significance and/or precision estimates? (e.g. p-values, confidence intervals)

11 Were the methods (including statistical methods) sufficiently described to enable them to be repeated?

Results

12 Were the basic data adequately described?

13 Does the response rate raise concerns about non-response bias?

14 If appropriate, was information about non-responders described?

15 Were the results internally consistent?

16 Were the results presented for all the analyses described in the methods?

Discussion

17 Were the authors' discussions and conclusions justified by the results?

18 Were the limitations of the study discussed?

Other

19 Were there any funding sources or conflicts of interest that may affect the authors’ interpretation of the results?

20 Was ethical approval or consent of participants attained?

Added from NIH tool for cross-sectional and cohort studies

21 Were the outcome assessors blinded to the exposure status of participants?

22 Was loss to follow-up after baseline 20% or less?

23 Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?