


REVIEW ARTICLE

Factors included in adult fall risk assessment tools (FRATs): a systematic review

Hendrika de Clercq^{1*} , Alida Naudé¹ and Juan Bornman¹

¹Centre for Augmentative and Alternative Communication, Faculty of Humanities, University of Pretoria, South Africa

*Corresponding author. Email: hendrika@hdcinc.co.za

(Accepted 24 March 2020; first published online 22 April 2020)

Abstract

Falls often have severe financial and environmental consequences, not only for those who fall, but also for their families and society at large. Identifying fall risk in older adults can be of great use in preventing or reducing falls and fall risk, and preventative measures that are then introduced can help reduce the incidence and severity of falls in older adults. The overall aim of our systematic review was to provide an analysis of existing mechanisms and measures for evaluating fall risk in older adults. The 43 included FRATs produced a total of 493 FRAT items which, when linked to the ICF, resulted in a total of 952 ICF codes. The ICF domain with the most used codes was body function, with 381 of the 952 codes used (40%), followed by activities and participation with 273 codes (28%), body structure with 238 codes (25%) and, lastly, environmental and personal factors with only 60 codes (7%). This review highlights the fact that current FRATs focus on the body, neglecting environmental and personal factors and, to a lesser extent, activities and participation. This over-reliance on the body as the point of failure in fall risk assessment clearly highlights the need for gathering qualitative data, such as from focus group discussions with older adults, to capture the perspectives and views of the older adults themselves about the factors that increase their risk of falling and comparing these perspectives to the data gathered from published FRATs as described in this review.

Keywords: accidental falls; aging/ageing; balance; disability and health; fall risk factors; fall risk assessment tools (FRATs)

Introduction

The ageing cohort of the world population is expected to increase at an unprecedented rate from approximately 8.5 per cent (617 million people) in 2015 to a projected 17 per cent (1.6 billion people) in 2050 (Stewart Williams *et al.*, 2015). Accidental falls are the leading cause of injury-related deaths among older adults of 65 years and older (LeCuyer *et al.*, 2016) and therefore of grave concern to all health-care practitioners and policy makers. Unsurprisingly, falls are one of the five so-called ‘geriatric giants’, along with dementia, poor mobility, incontinence and polypharmacy (Cumming,

2013). Internationally, it is estimated that a third of community-dwelling older people may experience accidental falls every year and among these fallers, 35.5 per cent may experience recurrent falls (Hung *et al.*, 2017). According to the Centers for Disease Control and Prevention, more than 2.7 million older adults are injured annually from falls in the United States of America (Homer *et al.*, 2017).

Older adults show a higher incidence and prevalence of falling and they also experience more severe complications after falls (Flaherty and Josephson, 2013), including medical, psychological and personal consequences. Medical consequences can be severe and include osteoporotic fractures, head injuries, impaired mobility, traumatic brain or head injury, increased risk of future falls, abrasions, lacerations, contusions and functional decline (Calys *et al.*, 2013; Flarity *et al.*, 2013; Wildes *et al.*, 2015; Callisaya *et al.*, 2016; Deschamps *et al.*, 2016; Dueñas *et al.*, 2016; Gu and Dennis, 2016; Kenny *et al.*, 2016; Romli *et al.*, 2017). The personal and psychological consequences of falls can be just as debilitating as the medical and physical consequences, and they do not only affect the older adult who falls, but also the immediate family and/or care-givers. Some of these consequences, as described in the literature, include fear of falling, depression, loss of independence, reduced quality of life, reduced participation in physical and social activities, immobility, early admission to nursing homes, difficulty with activities of daily living, dependency on others, social isolation, anxiety, loneliness, loss of confidence, loss of self-efficacy and decreased self-esteem (Ma *et al.*, 2014; Callisaya *et al.*, 2016; Deschamps *et al.*, 2016; Dueñas *et al.*, 2016; Greenberg *et al.*, 2016; Kenny *et al.*, 2016; Narayanan *et al.*, 2016; Palumbo *et al.*, 2016; Phelan *et al.*, 2015; Romli *et al.*, 2017). Other consequences of falls in older adults include financial and environmental factors such as hospitalisation, early admission to nursing homes, adaptation of the home environment, socio-economic burden on both the health-care system and the patients' relatives and prolonged rehabilitation (Da Costa *et al.*, 2012; Phelan *et al.*, 2015; Callisaya *et al.*, 2016; Dueñas *et al.*, 2016). Although age is one risk factor for falls, many other risk factors exist that could increase the likelihood that a person will fall (Phelan *et al.*, 2015), such as gait or balance disorders, dizziness, postural hypotension or environmental-related factors (Rubenstein, 2006). Some falls may be prevented if an older adult's risk of falling is identified before their first fall, and this can be done using one of several fall risk assessment tools (FRATs).

An older adult's risk of falling could be identified more effectively if a universal, standard language for measuring fall risk in the ageing population was available. The International Classification of Functioning, Disability and Health (ICF), which was endorsed by the World Health Organization in 2001, views functioning and disability as outcomes of interactions between the health condition (in this case, falls) and the contextual factors (in this case, fall risk factors), which include both personal and environmental risk factors (World Health Organization, 2002). The ICF aims to code a person's functioning and disability based on four categories, namely (a) body function; (b) body structure; (c) activities and participation; and (d) environmental and personal factors (Figure 1).

The ICF presents a scientific basis for understanding fall risk factors in older adults and provides a holistic model and universal language for health-care practitioners around the world to describe and classify falls and fall risk in older adults

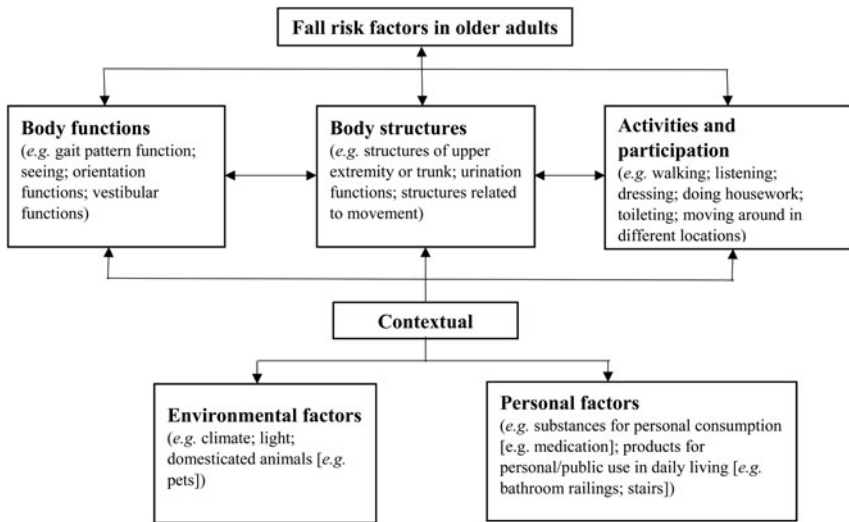


Figure 1. Fall risk factors in older adults in relation to the International Classification of Functioning, Disability and Health (ICF).

Source: Based on the ICF model (World Health Organization, 2002).

(World Health Organization, 2002). Since the ICF transcends professional boundaries across countries, it allows for clear interaction between professionals from different disciplinary backgrounds. It also enables them to discuss falls and fall risk factors without fear of miscommunication or bias due to selective, professional focus – thus increasing the possibility of early identification of fall risk in these individuals. The ICF is a systematic coding system for documenting health information, not simply about fall risk as a condition, but also for explaining how falls can affect the older adult in all aspects of life. It outlines the role of the environment and personal factors, and so allows health-care professionals to obtain a snapshot of the older adult's present health status (Granberg, 2015). Currently, most FRATs do not describe fall risk in terms of the ICF and there is a lack of information about fall risk assessment and the ICF, especially in community-dwelling older adults (Noohu *et al.*, 2017). Identifying fall risk factors in current FRATs may be one way to link fall risk assessment to the ICF and gain all the advantages of using the ICF as a model for discussing fall risk in older adults.

The overall aim of this systematic review was to provide an analysis of existing mechanisms and measures for evaluating fall risk in older adults. The specific objectives were (a) to identify factors that had been utilised to quantify fall risk in older adults by means of a FRAT; (b) to map the content of the identified measures (*i.e.* the fall risk factors) to ICF codes using the ICF linking rules; and (c) to compare the weighted focus of the FRATs items in relation to the body (body function and structure), the individual and society (activities and participation) and the impact of the environment on the individual (environmental and personal factors).

Method

A systematic review based on the five stages suggested by Arksey and O'Malley (2005) was conducted, and suggestions by Adair *et al.* (2018) were followed, who specifically aimed to identify measures and make recommendations for quality assessment. In Stage 1, the research question was identified and articulated as the aim of the review. In Stage 2, the search strategy that was followed involved identifying relevant studies and setting specific search parameters, such as the time and language of the articles. Stage 3 was the study selection which, for a systematic review, was articulated as the inclusion and exclusion criteria. During Stage 4, the data were charted using a customised data extraction sheet. Stage 5 involved collating, summarising and reporting the results as set out in the Results and Discussion section of this paper. The overall PRISMA methodology was included as this is an evidence-based minimum set of items for reporting in systematic reviews and meta-analysis (Moher *et al.*, 2009).

Search strategy and selection criteria

The structured database search included nine databases and platforms (WorldCat; Medline; PaperFirst; ScienceDirect; SA ePublications and Journal Collection; BioOne; JSTOR Health and General Sciences Collection; JSTOR Life Sciences Collection). The primary purpose was to compile a comprehensive list of published papers on fall risk assessment tools from the literature. The search terms used were *ti:(fall*) AND ti:(risk) AND ti:(assess*) AND ti:(tool*)*. No restriction in respect of date was placed on the search and all articles mentioning the keyword in the title were included in the initial set of results. Articles that had been published in languages other than English were excluded, due to the cost and time involved in translating such material.

Article screening and data extraction

The first author (HdC) performed the initial database search and screened the titles for potentially relevant articles. After screening the titles, the articles were exported to Rayyan, a Web-based systematic review program that allows different reviewers to work on the same project simultaneously and determine the agreement percentage between reviewers (Ouzzani *et al.*, 2016). The first and second authors (HdC and AN) then independently screened all the identified potential articles at title and abstract level, using the inclusion and exclusion criteria (Table 1). Any discrepancies related to the inclusion of articles were resolved through discussion, and if consensus could not be reached, the third author (JB) was available to review the article. All three reviewers are dually qualified as speech-language therapists and audiologists, and each has at least ten years' clinical experience.

A customised data extraction sheet was compiled to enable consistent and independent data reporting for the search. Data extraction included the article date, author and the names of the FRATs discussed in the article. Data extraction was completed by HdC and AN, and no discrepancies were noted at this level.

Thereafter, two sets of criteria were used for including FRATs in the factor-mapping process. First, the FRAT had to be available at no cost, it had to be named and it had to have a supporting reference in the articles identified in this

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria	Theoretical justification
Older adults	Paediatrics and obstetrics	This study focused on older adults, as fall is one of the geriatric giants (Cumming, 2013)
Available at no cost	Tools that have to be purchased	Tools that had to be bought were excluded due to the cost and time involved in purchasing the material (Arksey and O'Malley, 2005)
Assessment tools	Intervention studies	This study focused on assessment tools as a fall prevention strategy (World Health Organization, 2018) and not on the monitoring or intervention of fall risk assessment
Fall risk	Papers with main focus on a specific medical condition with a known fall risk	Risk factors for these medical conditions are not sensitive and specific enough to identify fall risk in the general population (World Health Organization, 2018)

review to allow it to be located. Second, only those FRATs reported in at least one of the articles identified in the review were included. It is possible that previous researchers frequently chose only 'popular' FRATs for assessing fall risk when designing a study, but for this review, we aimed to include all mentioned FRATs, even if the FRAT was mentioned in only one of the articles identified in the search. Thus, our data were not limited to frequently used FRATs only. Two reviewers (HdC and AN) independently reviewed 102 studies for inclusion and excluded 35 studies. Of the 143 articles identified in the initial database search, 125 were subjected to title-level screening, 111 were evaluated on abstract level and 102 articles were evaluated for inclusion on full-text level. Of the latter 102 articles, 67 were eventually included in the data extraction process where a total of 49 tools were identified and 43 tools were included in the results (Figure 2).

Quality assessment

Our systematic review did not aim to summarise the effectiveness of assessment tools, the risk of bias of studies or the quality of the methodology used to design the FRATs (Adair *et al.*, 2018). Given our focus on the identification of FRATs, no formal assessments of methodological quality or risk of bias of the included articles were performed.

Data analysis

The 67 studies included in the review were independently evaluated by two reviewers (HdC and AN) and a 100 per cent agreement score was obtained by these two reviewers. A total of 49 FRATs were identified to be included in the review. Of the 49 tools identified, six were excluded as the researchers were unable to obtain them (Jester *et al.*, 2005; Vassallo *et al.*, 2005; Young *et al.*, 2005; Scott

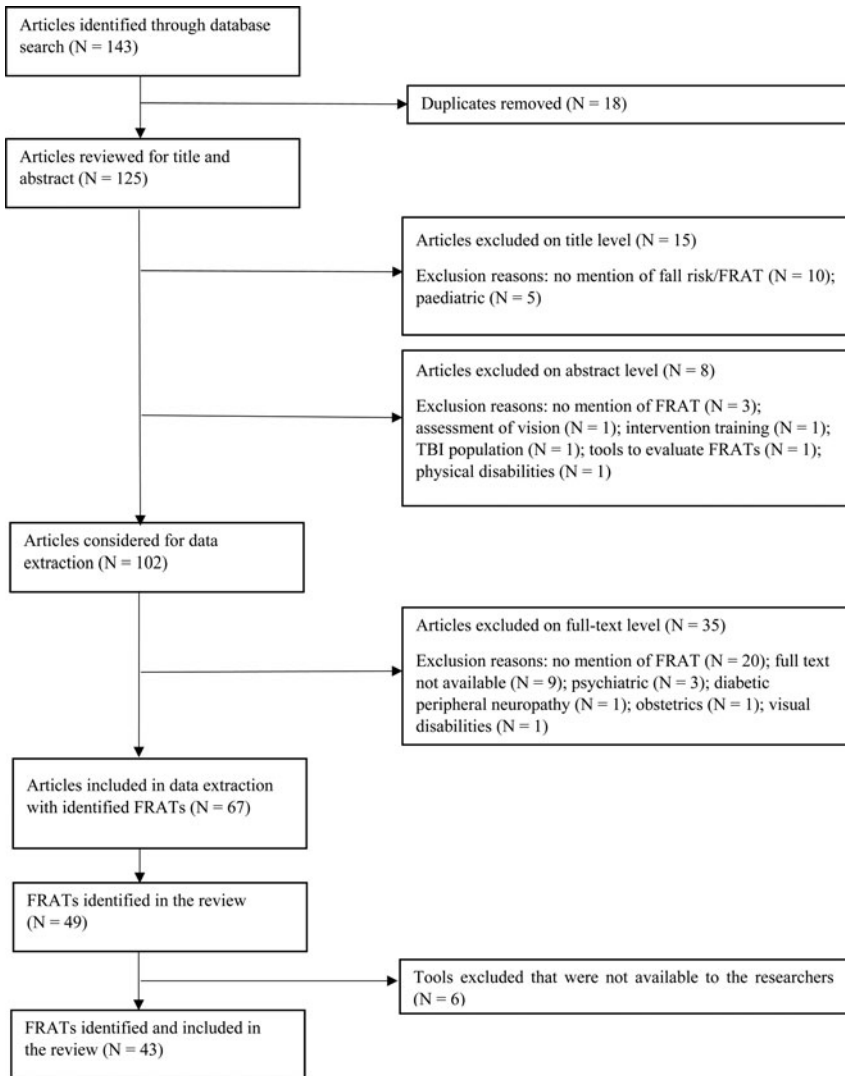


Figure 2. Graphic representation of the methodological process.

Notes: FRATs: fall risk assessment tools. TBI: traumatic brain injury.

et al., 2007; Hirase *et al.*, 2014; Miyakoshi *et al.*, 2014), despite contacting the corresponding authors of each article in which the tools were mentioned. The 43 FRATs included in the review were analysed by the first author (HdC) and the items in each tool were identified and extracted via Microsoft® Office Excel. All the tools were independently evaluated by all three reviewers (HdC, AN and JB) and an initial agreement of 92 per cent was established. After discussion of the discrepancies, the reviewers fully agreed on the ICF codes to which each item in the FRATs had been linked, using the ICF linking rules.

Items were linked to corresponding ICF categories by using the ten ICF rules for linking the relevant health information included in instruments and tools to the corresponding ICF categories (Selb *et al.*, 2015; Cieza *et al.*, 2016). The first seven linking rules were applied in this study: Rule 1 – acquiring good knowledge of the conceptual fundamentals of the ICF; Rule 2 – identifying the main concept of each item to be linked to the ICF; Rule 3 – identifying additional concepts for each item if needed; Rule 4 – considering the popular perspectives for each identified concept when collecting health-related information; Rule 5 – identifying and document the categorisation of the response options; Rule 6 – linking all meaningful concepts to the precise ICF category; and Rule 7 – using ‘other specific’ or ‘unspecified’ ICD categories as appropriate. Rules 8–10 are only used when a specific code is not available on the third or fourth ICF level. For the purposes of this review, a two-level ICF classification was sufficient (Rules 1– 7) and further classification was not required at the time. All three reviewers independently linked the identified FRAT factors to the corresponding ICF categories. The weighted focus of the FRAT items in relation to the ICF categories was calculated using the confidence intervals to determine the *p*-values.

Results

On completion of the data extraction, a summary was made of the 43 FRATs included in the review, based on the included 67 articles (*see* Table 2). These 43 FRATs were categorised according to where their focus lay with regards to the four ICF categories, namely the body (where body function and structure codes are grouped together), the level of the individual (activities and participation) and the impact of the environment on the individual (environmental and personal factors).

As depicted in Table 2, a total of 43 FRATs were identified. The five FRATs mentioned most often in the review were the Stratify (N = 17), Morse Fall Scale (N = 15), Timed Up and Go (N = 13), Hendrich II Fall Risk Assessment Tool (N = 13) and the Tinetti Balance Assessment Tool (N = 10). Nine tools were mentioned three to eight times, namely the Berg Balance Scale (N = 9), Downton Index (N = 8), Johns Hopkins Fall Risk Assessment Tool (N = 7), Conley Scale (N = 6), Mobility Interaction Fall Chart (N = 6), Functional Reach (N = 5), Dynamic Gait Index (N = 4), FROP-Com (N = 4) and the Melbourne Fall Risk Assessment Tool (N = 3). Eight other FRATs were only mentioned twice, while 21 FRATs (49%) were mentioned only once in the review. A total of 18 tools – developed between 1986 and 1999 – were mentioned in 70 per cent of the articles being reviewed, whereas the 25 tools developed between 2000 and 2018 were mentioned in only 30 per cent of the articles in this review.

Of all 43 FRATs, 39 (91%) focused mainly on the body (body function and structure), while only one tool (LASA Fall Risk Profile) focused mainly on activities and participation (56%). Another tool (Marianjoy FRAT) focused equally (46%) on body function and structure and on activities and participation; the MAHC-10 focused mainly on environmental and personal factors (47%); and the Thai FRAT focused equally (40%) on body function and structure as well as on environmental and personal factors.

Table 2. Summary of included fall risk assessment tools (FRATs) presented in alphabetical order

FRAT name	N	Original reference	Date when developed	ICF focus ¹
10 Meter Walk Test	2 (Renfro <i>et al.</i> , 2016; Lee and Kim, 2017)	Bohannon <i>et al.</i> (1996)	1996	BF&S: 67% ; A&P: 33%; E&P: 0%
13-point FRAT	1 (Chang <i>et al.</i> , 2018)	Chang <i>et al.</i> (2018)	2000	BF&S: 75% ; A&P: 0%; E&P: 25%
30-Second Chair Test	2 (Scott <i>et al.</i> , 2007; Chow <i>et al.</i> , 2018)	Jones <i>et al.</i> (1999)	1999	BF&S: 67% ; A&P: 33%; E&P: 0%
Activities-specific Balance Confidence (ABC) scale	1 (Park, 2017)	Powell and Myers (1995)	1995	BF&S: 75% ; A&P: 20%; E&P: 5%
Ballarat Health Service FRAT	1 (Wong Shee <i>et al.</i> , 2012)	Wong Shee <i>et al.</i> (2012)	2010	BF&S: 69% ; A&P: 25%; E&P: 6%
Berg Balance Scale	9 (Stretanski <i>et al.</i> 2002; Scott <i>et al.</i> , 2007; Zhang and Lockhart, 2009; Hirase <i>et al.</i> , 2014; Palumbo <i>et al.</i> 2015; Renfro <i>et al.</i> , 2016; Kim and Xiong, 2017; Lee and Kim, 2017; Park, 2017)	Berg <i>et al.</i> (1989)	1989	BF&S: 67% ; A&P: 33%; E&P: 0%
BESTest	2 (Renfro <i>et al.</i> , 2016; Kim and Xiong, 2017)	Horak <i>et al.</i> (2009)	2009	BF&S: 67% ; A&P: 33%; E&P: 0%
Conley Scale	6 (Scott <i>et al.</i> , 2007; Lovallo <i>et al.</i> , 2010; Flarity <i>et al.</i> , 2013; Guzzo <i>et al.</i> , 2015; Majkusova and Jarosova, 2017; Park, 2017)	Conley <i>et al.</i> (1999)	1999	BF&S: 70% ; A&P: 25%; E&P: 5%
Demura's Fall Risk Assessment	1 (Park, 2017)	Demura <i>et al.</i> (2010)	2010	BF&S: 67% ; A&P: 27%; E&P: 6%

(Continued)

Table 2. (Continued.)

FRAT name	N	Original reference	Date when developed	ICF focus ¹
Downton Index	8 (Meyer <i>et al.</i> , 2005, 2009; Vassallo <i>et al.</i> , 2005, 2008; Scott <i>et al.</i> , 2007; Salb <i>et al.</i> , 2015; Majkusova and Jarosova, 2017; Nunan <i>et al.</i> , 2018)	Downton (1993)	1993	BF&S: 67% ; A&P: 16.5%; E&P: 16.5%
Dynamic Gait Index (DGI)	4 (Scott <i>et al.</i> , 2007; Zhang and Lockhart, 2009; Renfro <i>et al.</i> , 2016; Park, 2017)	Whitney <i>et al.</i> (2005)	2005	BF&S: 67% ; A&P: 33%; E&P: 0%
Falls Assessment Risk and Management (FARAM)	1 (Barker <i>et al.</i> , 2009)	Western Australia Department of Health (2015)	2004	BF&S: 64% ; A&P: 18%; E&P: 18%
Falls Efficacy Scale (FES)	2 (Scott <i>et al.</i> , 2007; Kim and Xiong, 2017)	Yardley <i>et al.</i> (2005)	2005	BF&S: 59% ; A&P: 35%; E&P: 6%
Falls Risk Assessment and Management Plan (FRAMP)	1 (Delfante <i>et al.</i> , 2018)	Western Australia Department of Health (2015)	2010	BF&S: 54% ; A&P: 36%; E&P: 9%
Four Square Step Test	1 (Hirase <i>et al.</i> , 2014)	Dite and Temple (2002)	2002	BF&S: 67% ; A&P: 33%; E&P: 0%
FRHOP Risk Assessment Tool	1 (Hill <i>et al.</i> , 2004)	Collins <i>et al.</i> (2004)	2004	BF&S: 47% ; A&P: 35%; E&P: 18%
FROP-Com	4 (Russell <i>et al.</i> , 2006, 2008; Park, 2017; Teh <i>et al.</i> , 2017)	Moore K, Fearn M, Cyarto E, Renehan E <i>et al.</i> (2006)	2009	BF&S: 58% ; A&P: 26%; E&P: 16%
Fullerton Advanced Balance (FAB) scale	1 (Park, 2017)	Rose <i>et al.</i> (2006)	2006	BF&S: 67% ; A&P: 33%; E&P: 0%

Functional Independence Measure (FIM)	1 (Forrest <i>et al.</i> , 2013)	McDowell and Newell (1996)	1996	BF&S: 58%; A&P: 42%; E&P: 0%
Functional Reach (FR)	5 (Scott <i>et al.</i> , 2007; Russell <i>et al.</i> , 2008; Yamashita <i>et al.</i> , 2016; Kim and Xiong, 2017; Lee and Kim, 2017)	Duncan <i>et al.</i> (1990)	1990	BF&S: 67%; A&P: 33%; E&P: 0%
Hendrich II FRAT	13 (EA Kim <i>et al.</i> , 2007; Lovallo <i>et al.</i> , 2010; Chapman <i>et al.</i> , 2011; Flarity <i>et al.</i> , 2013; SR Kim <i>et al.</i> , 2013; Higaonna, 2015; Selb <i>et al.</i> , 2015; McNair and Simpson, 2016; Higaonna <i>et al.</i> , 2017; Kim and Xiong, 2017; Majkusova and Jarosova, 2017; Park, 2017; Baran and Gunes, 2018)	Hendrich <i>et al.</i> (1995)	1995	BF&S: 64%; A&P: 27%; E&P: 9%
Johns Hopkins FRAT	7 (Poe <i>et al.</i> , 2007; Flarity <i>et al.</i> , 2013; Hnizdo <i>et al.</i> , 2013; Hur <i>et al.</i> , 2016; Zhang <i>et al.</i> , 2016; Klinkenberg and Potter, 2017; Park, 2017)	Poe <i>et al.</i> (2005)	2003	BF&S: 58%; A&P: 32%; E&P: 10%
LASA Fall Risk Profile	1 (Park, 2017)	Pluijm <i>et al.</i> (2006)	2006	BF&S: 22%; A&P: 56%; E&P: 22%
Marianjoy FRAT	1 (Ruroede <i>et al.</i> , 2016)	Ruroede <i>et al.</i> (2016)	2000	BF&S: 46%; A&P: 46%; E&P: 8%
Melbourne FRAT	3 (Barker <i>et al.</i> , 2009; Narayanan <i>et al.</i> , 2016; Nunan <i>et al.</i> , 2018)	Royal Melbourne Hospital (1995)	1995	BF&S: 56%; A&P: 33%; E&P: 11%
Missouri Alliance for Home Care fall risk assessment tool (MAHC-10)	2 (Calys <i>et al.</i> , 2013; Gallagher <i>et al.</i> , 2013)	Calys <i>et al.</i> , (2013)	2010	BF&S: 35%; A&P: 18%; E&P: 47%
Mobility Interaction Fall (MIF) chart	6 (Lundin-Olsson <i>et al.</i> , 2003; Meyer <i>et al.</i> , 2005; Scott <i>et al.</i> , 2007; Kehinde, 2009; Park, 2017; Nunan <i>et al.</i> , 2018)	Lundin-Olsson <i>et al.</i> (2006)	2000	BF&S: 56%; A&P: 33%; E&P: 11%;

(Continued)

Table 2. (Continued.)

FRAT name	N	Original reference	Date when developed	ICF focus ¹
Modified Gait Abnormality Rating Scale	1 (Zhang and Lockhart, 2009)	Van Swearingen <i>et al.</i> (1996)	1996	BF&S: 67%; A&P: 33%; E&P: 0%
Morse Fall Scale	15 (EA Kim <i>et al.</i> , 2007; Poe <i>et al.</i> , 2007; Kehinde, 2009; Chapman <i>et al.</i> , 2011; Flarity <i>et al.</i> , 2013; Forrest <i>et al.</i> , 2013; SR Kim <i>et al.</i> , 2013; Higaonna, 2015; Salb <i>et al.</i> , 2015; Higaonna <i>et al.</i> , 2017; Kim and Xiong, 2017; Majkusova and Jarosova, 2017; Park, 2017)	Morse <i>et al.</i> (1989)	1989	BF&S: 53%; A&P: 20%; E&P: 27%
New York-Presbyterian Fall and Injury Risk Assessment Tool	2 (Chapman <i>et al.</i> , 2011; Salb <i>et al.</i> , 2015)	Currie <i>et al.</i> (2004)	2004	BF&S: 75%; A&P: 25%; E&P: 0%
Peninsula Health FRAT	2 (Barker <i>et al.</i> , 2009; Nunan <i>et al.</i> , 2018)	Stapleton <i>et al.</i> (2009)	1999	BF&S: 54%; A&P: 35%; E&P: 11%
Queensland FRAT	2 (Park, 2017; Nunan <i>et al.</i> , 2018)	Peel <i>et al.</i> (2008)	2007	BF&S: 57%; A&P: 29%; E&P: 14%
Quickscreen	1 (Tiedemann <i>et al.</i> , 2012)	Tiedemann (2006)	2004	BF&S: 62%; A&P: 30%; E&P: 8%
Schmid Fall Risk Assessment	1 (Park, 2017)	Schmid (1990)	1990	BF&S: 50%; A&P: 33%; E&P: 17%
Short Physical Performance Battery (SPPB)	1 (Park, 2017)	Guralnik <i>et al.</i> (1994)	1994	BF&S: 67%; A&P: 33%; E&P: 0%

Spartanburg FRAT (SFRAT)	1 (Robey-Williams <i>et al.</i> , 2007)	Robey-Williams <i>et al.</i> (2007)	2007	BF&S: 57% ; A&P: 29%; E&P: 14%
Stratify	17 (Oliver <i>et al.</i> , 1997; Hill <i>et al.</i> , 2004; Papaioannou <i>et al.</i> , 2004; Jester <i>et al.</i> , 2005; Seneviratne, 2006; EA Kim <i>et al.</i> , 2007; Scott <i>et al.</i> , 2007; Vassallo <i>et al.</i> , 2008; Wong Shee <i>et al.</i> , 2012; SR Kim <i>et al.</i> , 2013; Skelton <i>et al.</i> , 2014; Guzzo <i>et al.</i> , 2015; Higaonna, 2015; Higaonna <i>et al.</i> , 2017; Kim and Xiong, 2017; Majkusova and Jarosova, 2017; Park, 2017)	Oliver <i>et al.</i> (1997)	1997	BF&S: 57% ; A&P: 43%; E&P: 0%
Thai FRAT	1 (Park, 2017)	Thiamwong <i>et al.</i> (2009)	2009	BF&S: 40% ; A&P: 20%; E&P: 40%
Timed Up and Go (TUG)	13 (Scott <i>et al.</i> , 2007; Zhang and Lockhart, 2009; Hirase <i>et al.</i> , 2014; Cattalani <i>et al.</i> , 2015; Renfro <i>et al.</i> , 2016; Kim and Xiong, 2017; Lee and Kim, 2017; Park, 2017)	Podsiadlo and Richardson (1991)	1991	BF&S: 67% ; A&P: 33%; E&P: 0%
Tinetti Balance Assessment Tool (POMA)	10 (Meyer <i>et al.</i> , 2005; Vassallo <i>et al.</i> , 2005; Flarity <i>et al.</i> , 2013; Gallagher <i>et al.</i> , 2013; Hirase <i>et al.</i> , 2014; Renfro <i>et al.</i> , 2016; Kim and Xiong, 2017; Lee and Kim, 2017; Majkusova and Jarosova, 2017; Park, 2017)	Tinetti <i>et al.</i> (1986)	1986	BF&S: 67% ; A&P: 33%; E&P: 0%
Traffic Light FRAT	1 (Chang <i>et al.</i> , 2018)	Chang <i>et al.</i> (2018)	2018	BF&S: 75% ; A&P: 25%; E&P: 0%
Walking While Talking (WWT)	1 (Park, 2017)	Verghese <i>et al.</i> (2002)	2002	BF&S: 72% ; A&P: 28%; E&P: 0%
Zur Balance Scale	1 (Park, 2017)	Zur <i>et al.</i> (2016)	2016	BF&S: 67% ; A&P: 33%; E&P: 0%

Notes: N = 67 articles. ICF: International Classification of Functioning, Disability and Health. BF&S: body function and structure. A&P: activities and participation. E&P: environmental and personal factors. 1. The main focus is indicated in bold.

The items included in each of the 43 FRATs were extracted and linked to the ICF codes using the ICF linking rules (Cieza *et al.*, 2016). Each item was categorised based on body function, body structure, activities and participation, and environmental and personal factors. The 43 FRATs produced a total of 493 FRAT items, which were linked to a total of 952 ICF codes (summarised as shown in Table 3).

Table 3 depicts the ICF codes extracted from the included FRATs, arranged from most used codes to least used codes. The domain with the most used codes was body function with 381 of the 952 codes used (40%), followed by activities and participation with 273 codes (28%), body structure with 238 codes (25%) and, lastly, environmental and personal factors with only 60 codes (7%). As the body functions and structures are interlinked and both relate to the body, their codes were summed, which resulted in 619 codes and accounted for 65 per cent of the codes identified in the review. The differences between the statistical significance of these groups were calculated to determine the weighted focus of the FRAT items in each ICF category (Table 4).

Based on these values, a statistically significant p -value of $p < 0.0001$ and a 95 per cent confidence interval of the difference were reported among all three groups (Table 4), namely body function and structure ($N = 619$) compared to activities and participation ($N = 273$); activities and participation ($N = 273$) compared to environmental and personal factors ($N = 60$); and body function and structure ($N = 619$) compared to environmental and personal factors ($N = 60$) (Altman, 1991).

Discussion

In this review, the overall aim was to provide an analysis of existing mechanisms and measures for evaluating fall risk in older adults. We identified the factors in FRATs that are currently available in the literature and mapped these fall risk factors to the ICF. Results indicated that the majority of the linked factors focused on the domain of the body (body function and structure), followed by the activities and participation domain and lastly on the environmental factors. All but four FRATs focused mainly on the body, indicating that ‘the body’ is regarded as the point of failure and of risk in most currently available FRATs.

However, contemporary research is emerging to show that other factors – factors outside the body, such as environmental factors, present immediately prior to and during falls – could hold as much, if not more, significant risks (Klenk *et al.*, 2017). In-depth knowledge of falls in older adults therefore needs further development to consider environmental fall risk factors adequately. A recent study by Noohu *et al.* (2017) agreed with this notion and mentioned that the strongest predictor of a single fall is limitations in both the activities and participation and in the environmental domain, whereas multiple falls are best predicted with limitations in the activities and participation domain. This emphasises the fact that more emphasis needs to be placed on factors other than those related to the body, such as environmental factors and limitations surrounding an individual’s ability to perform activities and participate in life situations.

Based on the results of this review and the strong focus on the body as the main contributor to falls in older adults, almost all freely available FRATs which focus on

Table 3. Summary of International Classification of Functioning, Disability and Health (ICF) codes linked to included fall risk assessment tools

Body function		Body structure		Activities and participation		Environmental and personal factors	
ICF code	N	ICF code	N	ICF code	N	ICF code	N
b760 – control of voluntary movement	106	s770 – additional musculoskeletal structures related to movement	92	d460 – moving around in different locations	53	e110 – products or substances for personal consumption	21
b770 – gait pattern function	59	s798 – structures related to movement	81	d415 – maintaining a body position	38	e120 – products and technology for personal indoor and outdoor mobility and transportation	11
b210 – seeing	35	s750 – structure of lower extremity	22	d110 – watching	34	e115 – products and technology for personal use in daily living	7
b126 – temperament and personality functions	19	s260 – structure of inner ear	19	d410 – changing basic body position	33	e298 – natural environment and human-made changes to environment; other	6
b235 – vestibular functions	19	s610 – structures of urinary system	16	d530 – toileting	32	e150 – design, construction and building products and technology of buildings for public use	4
b260 – proprioception functions	19	s760 – structures of the trunk	3	d420 – transferring oneself	14	e155 – design, construction and building products and technology of buildings for private use	4
b525 – defecation function	16	s730 – structure of upper extremity	2	d445 – hand and arm use	12	e255 – climate	2
b610 – urination functions	16	s799 – structures related to movement, unspecified	2	d450 – walking	11	e340 – personal care providers and personal assistants	2

(Continued)

Table 3. (Continued.)

Body function		Body structure		Activities and participation		Environmental and personal factors	
ICF code	N	ICF code	N	ICF code	N	ICF code	N
b122 – global psycho-social functions	11	s430 – structures of respiratory system	1	d429 – changing and maintaining a body position, unspecified	8	e140 – products and technology for culture, recreation and sport	1
b749 – muscle functions	10			d455 – moving around	7	e240 – light	1
b755 – involuntary movement reaction functions	8			d115 – listening	6	e350 – domesticated animals	1
b114 – orientation functions	7			d540 – dressing	3		
b139 – global mental health functions	7			d640 – doing housework	3		
b152 – emotional functions	7			d230 – carrying out daily routine	2		
b230 – hearing	6			d310 – communicating with – receiving – spoken message	2		
b420 – sensations associated with hearing and vestibular functions	6			d330 – speaking	2		
b156 – perceptual functions	5			d510 – washing oneself	2		
b117 – intellectual functions	3			d570 – looking after one's health	2		
b279 – additional sensory functions	3			d571 – looking after one's safety	2		
b530 – weight management functions	3			d920 – recreation and leisure	2		

b740 – muscle endurance functions	3		d430 – lifting and carrying objects	1
b798 – neuromusculoskeletal- and movement-related functions	3		d465 – moving around using equipment	1
b144 – memory functions	2		d620 – acquisition of goods and services	1
b280 – sensations of pain	2		d630 – preparing meals	1
b125 – activity level	1		d650 – caring for household objects	1
b134 – sleep functions	1			
b147 – psychomotor functions	1			
b163 – basic cognitive functions	1			
b460 – sensations associated with cardiovascular and respiratory functions	1			
b715 – stability of joint functions	1			
Total	381	238	273	60

Table 4. Statistical differences between groups

Pairs	95% CI of the difference		<i>p</i>
	Lower	Upper	
Pair 1: Body function and structure (N = 619) – Activities and participation (N = 273)	–381.0090	–380.9910	<0.001
Pair 2: Activities and participation (N = 273) – Environmental and personal factors (N = 60)	177.9910	178.0090	<0.001
Pair 3: Body function and structure (N = 619) – Environmental and personal factors (N = 60)	–559.0090	–558.9910	<0.001

Note: CI: confidence interval.

the medical factors and model of assessment neglect considering the contributions of the biopsychosocial model of assessment. Viewing dysfunction through the narrow focus of the medical model (which is strictly concerned with organic dysfunctions) can easily translate to health-care professionals being concerned only with the physical aspects of disease (Farre and Rapley, 2017), which is translated as ‘the body’ in the ICF. This can place a limitation on the conceptual thinking about assessing fall risk in older adults as it obscures the fact that fall risk assessment in older adults is a collaboration between health-care professionals and older adults, and not just a medical procedure (Légaré *et al.*, 2018). Health-care professionals could address the older adults’ needs more comprehensively by assessing all areas in their lives that could contribute to and increase their risk of falling. Otherwise, by focusing purely on the medical or body aspects when discussing fall risk in older adults, the assessment and intervention process can easily become restrictive as the medical model for intervention is inadequate (Jensen, 2006). Although a need for further research to address problems in implementing a biopsychosocial model to assessment and intervention remains, changes could be facilitated by bringing evidence-based research to health-care professionals on the needs of specific populations (Farre and Rapley, 2017), such as older adults with a risk of falling.

By shifting the focus away from cause towards impact – such as the impact of the limitations in older adults’ ability to participate in life situations and engage in activities – all health conditions are placed on an equal footing and allowed to be compared using a common metric, the ruler of health and disability (World Health Organization, 2002). When fall risk in older adults is assessed through the lens of the impact of the condition on the individual, older adults are viewed holistically by also considering the activities in which they participate and the environment in which these activities take place. Hence, the ICF highlights the value of including not only activities and participation, but also the impact of environmental and personal factors on a person’s abilities in the assessment of health, thereby reiterating that the focus of FRATs should also move towards including these factors. Our results indicated that of the 22 FRATs developed after 2001, all but three FRATs still focused mainly on the body. By neglecting to focus on the individual and environmental levels when assessing fall risk in older adults, important factors, such as quality of life, participation in activities, housing, family

caring and even access to health-care services, could be omitted in the older adult's intervention plan.

We found that only a minimal number of codes representative of the environmental influence of fall risk were represented in the FRATs. Within this small number of environmental codes, the majority of these codes were linked to the use of medication. So even when the effects of personal and environmental factors on fall risk is mentioned, the impact of the medical model is still prevalent in the significant number of codes mentioning medication. This could also be because a vast amount of research has been done on the topic of fall risk and medication use. By moving away from the medical model, towards a biopsychosocial model, even our knowledge of the environmental and personal effect of falls on older adults could be enhanced. A major part of existing literature focuses on risk factors in isolation (Ek, 2019), ignoring possible interactions that other factors could have on older adults' fall risk. As risk factors seem to cluster within older adults, it is suggested that both the clinical and research focus of assessing fall risk in older adults should focus more on the whole risk profile of the individual as well as on the effect of cumulative risk, rather than on isolated, medical risk factors (Ek, 2019).

This begs the question of whether activities and participation, as well as environmental and personal influences, do not perhaps play a bigger role in increased risk of falling than is currently addressed by available FRATs. The medical focus of the most popular tools used could also discourage health-care professionals from adopting a more biopsychosocial model as they continue to use – on a regular basis – FRATs focused on the medical model. This could be because health-care professionals see the available and validated FRATs as reliable and do not feel the need to search beyond these factors. Health-care professionals should be able and ready to evaluate all factors contributing to a condition, not only the ones they are used to, and also not just the factors supporting a biological or organic cause of the condition (Farre and Rapley, 2017). By moving away from a medical model and towards a biopsychosocial model such as the ICF, it is during intervention possible to evaluate and consider the effects of fall risk on activities and participation in older adults, as well as the contributing environmental and personal factors.

One way of moving the discourse around environmental and personal factors on fall risk assessment forward could be to capture the perspectives and views of the older adults themselves about their perceptions on their own risk of falling in a qualitative research study on how fall risk assessment in older adults could be improved. As falls and fall risk is a multi-dimensional construct, particularly in older adults, a comprehensive ICF-based FRAT, that not only reflects a medical perspective (with a focus on the body), but that also captures older adults' perceptions and views about individual factors (related to activities and participation), as well as the influence of the environment, could lead to a more holistic assessment and intervention focus in future.

Limitations of this review

This review did not include all the FRATs identified in the search, as some tools (N = 6) were not available to the researchers. It also did not include only standardised tests, but all FRATs – regardless of normative data. Many of the included

FRATs (N = 29) were only mentioned in one or two of the included studies, which may have influenced the data extraction. No computer-based FRATs were included, which may have resulted in some FRATs, such as the Aachen fall prevention app (Pape *et al.*, 2015), not being included in our review. Only FRATs aimed at the adult population were included in the review and all FRATs based on a specific medical condition (*e.g.* traumatic brain injury, physical disabilities, visual disabilities, diabetic peripheral neuropathy) were excluded.

Recommendations and conclusion

This review highlighted the fact that current FRATs focus on the body, neglecting environmental and personal factors and, to a lesser extent, activities and participation. This over-reliance on the body as the point of failure in fall risk assessment clearly highlights the need for gathering qualitative data, such as from focus group discussions with older adults, to capture the perspectives and views of the older adults themselves about the factors that increase their risk of falling and comparing these perspectives to the data gathered from published FRATs as described in this review.

Furthermore, fall risk assessment should be a multi-disciplinary approach and, as such, data from different disciplinary backgrounds should be collected to determine the factors related to fall risk as identified by each discipline that is involved in fall risk assessment of older adults. The FRATs identified in this review were mostly aimed at the hospital setting, whereas future research should include data for fall risk assessment among community-dwelling older adults, as more and more older adults choose to live in these contexts for a longer period of their lives. Future qualitative research could enhance our knowledge of the experiences of older adults with regard to fall risk and how to address older adults' needs better. Insight into the perceptions of older adults relating to fall risk could expand the body of knowledge on falls, related injuries and preventive measures for both older adults and the professionals working with them (Gamage *et al.*, 2018).

Acknowledgements. The financial assistance of the National Institute for the Humanities and Social Sciences (NIHSS), in collaboration with the South African Humanities Deans Association (SAHUDA), towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at are those of the authors and are not necessarily to be attributed to the NIHSS and SAHUDA.

Author contributions. All three authors were equally involved in the production of the article and read the final manuscript.

Financial support. This work was supported by a scholarship from the National Institute for Humanities and Social Sciences (HdC).

Conflict of interest. The authors declare no conflicts of interest.

References

Adair B, Ullenhag A, Rosenbaum P, Granlund M, Keen D and Imms C (2018) Measures used to quantify participation in childhood disability and their alignment with the family of participation-related constructs: a systematic review. *Developmental Medicine & Child Neurology* **60**, 1101–1116.

- Altman DG** (1991) *Practical Statistics for Medical Research*. London: Chapman and Hall.
- Arksey H and O'Malley L** (2005) Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology: Theory and Practice* **8**, 19–32.
- Baran L and Gunes U** (2018) Predictive validity of three fall risk assessment tools in nursing home residents in Turkey: a comparison of the psychometric properties. *International Journal of Caring Sciences* **11**, 36–44.
- Barker AL, Nitz JC, Low Choy NL and Haines T** (2009) Measuring fall risk and predicting who will fall: clinimetric properties of four fall risk assessment tools for residential aged care. *Journals of Gerontology: Biological Sciences and Medical Sciences* **64A**, 916–924.
- Berg K, Wood-Dauphinée S, Williams JI and Gayton D** (1989) Measuring balance in the elderly: preliminary development of an instrument. *Physiotherapy Canada* **41**, 304–311.
- Bohannon RW, Andrews AW and Thomas MW** (1996) Walking speed: reference values and correlates for older adults. *Journal of Orthopaedic & Sports Physical Therapy* **24**, 86–90.
- Callisaya ML, Blizzard L, Martin K and Srikanth VK** (2016) Gait initiation time is associated with the risk of multiple falls – a population-based study. *Gait and Posture* **49**, 19–24.
- Calys M, Gagnon K and Jernigan S** (2013) A validation study of the Missouri Alliance for Home Care Fall Risk Assessment Tool. *Home Health Care Management & Practice* **25**, 39–44.
- Cattalani L, Palumbo P, Palmerini L, Bandinelli S, Becker C, Chesani F and Chiari L** (2015) FRAT-up, a fall-risk assessment tool for elderly people living in the community. *Journal of Medical Internet Research* **17**, 41–45.
- Chang SY, Chen W, Teng T, Yeh C and Yen H** (2018) Fall risk program for oncology inpatients: addition of the 'Traffic Light' Fall Risk Assessment Tool. *Journal of Nursing Care Quality* **34**, 139–144.
- Chapman J, Bachand D and Hyrkas K** (2011) Testing the sensitivity, specificity and feasibility of four falls risk assessment tools in a clinical setting: falls risk assessment. *Journal of Nursing Management* **19**, 133–142.
- Chow RB, Lee A, Kane BG, Jacoby JL, Barraco RD, Dusza SW, Meyers MC, Greenberg MR. et al.** (2018) Effectiveness of the Timed Up and Go (TUG) and the Chair test as screening tools for geriatric fall risk assessment in the ED. *American Journal of Emergency Medicine* **37**, 457–460.
- Cieza A, Fayed N, Bickenbach J and Prodinger B** (2016) Refinements of the ICF Linking Rules to strengthen their potential for establishing comparability of health information. *Disability and Rehabilitation* **41**, 574–583.
- Collins T, McGann A, Jessup R, Vratsidis F, Hill KD and Pearce J** (2004) Validation of a falls risk assessment tool in the sub-acute hospital setting: a pilot study. *Australasian Journal of Podiatric Medicine* **38**, 99–108.
- Conley D, Schultz AA and Selvin R** (1999) The challenge of predicting patients at risk for falling: development of the Conley Scale. *MedSurg Nursing* **8**, 348–354.
- Cumming RG** (2013) Fall prevention in older persons. *CME* **31**, 378–381.
- Currie LM, Mellino LV, Cimino JJ and Bakken S.** (2004) Development and representation of a fall-injury risk assessment instrument in a clinical information system. In Fieschi M, Coiera E and Li YJ (eds), pp. 721–725. Amsterdam: IOS Press.
- Da Costa BR, Rutjes AWS, Mendy A, Freund-Heritage R and Vieira ER** (2012) Can falls risk prediction tools correctly identify fall-prone elderly rehabilitation in patients? A systematic review and meta-analysis. *PLOS ONE* **7**, 41–47.
- Delfante B, Patel H, Zake A and Emmerton L** (2018) A retrospective audit evaluating the effectiveness of a falls risk assessment tool. *Research in Social and Administrative Pharmacy* **14**, 33.
- Demura S, Sato S, Yokoya T and Sato T** (2010) Examination of useful items for the assessment of fall risk in the community-dwelling elderly Japanese population. *Environmental Health and Preventive Medicine* **15**, 169–179.
- Deschamps T, Le Goff CG, Berrut G, Cornu C and Mignardot JB** (2016) A decision model to predict the risk of the first fall onset. *Experimental Gerontology* **81**, 51–55.
- Dite W and Temple VA** (2002) A clinical test of stepping and change of direction to identify multiple falling older adults. *Archives of Physical Medicine and Rehabilitation* **83**, 1566–1571.
- Downton JH** (1993) *Falls in the Elderly*. Sevenoaks, UK: Edward Arnold.
- Dueñas L, Balasch i Bernat M, Mena del Horno S, Aguilar-Rodríguez M and Alcántara E** (2016) Development of predictive models for the estimation of the probability of suffering fear of falling and other fall risk factors based on posturography parameters in community-dwelling older adults. *International Journal of Industrial Ergonomics* **54**, 131–138.

- Duncan PW, Weiner DK, Chandler J and Studenski S** (1990) Functional reach: a new clinical measure of balance. *Journal of Gerontology* **45**, 192–197.
- Ek S** (2019) *Predictors and Consequences of Injurious Falls Among Older Adults: A Holistic Approach*. Solna, Sweden: The Aging Research Center (ARC), Department of Neurobiology, Care Sciences and Society, Karolinska Institute.
- Farre A and Rapley T** (2017) The new old (and old new) medical model: four decades navigating the biomedical and psychosocial understandings of health and illness. *Healthcare* **5**, 1–9.
- Flaherty LM and Josephson NC** (2013) Screening for fall risk in patients with haemophilia. *Haemophilia* **19**, 103–109.
- Flarity K, Pate T and Finch H** (2013) Development and implementation of the Memorial Emergency Department Fall Risk Assessment Tool. *Advanced Emergency Nursing Journal* **35**, 57–66.
- Forrest G, Chen E, Huss S and Giesler A** (2013) A comparison of the Functional Independence Measure and Morse Fall Scale as tools to assess risk of fall on an inpatient rehabilitation. *Rehabilitation Nursing* **38**, 186–192.
- Gallagher R, Stith N and Southard V** (2013) Evaluation of the Missouri Alliance for Home Care Fall Risk Assessment Tool and home-based ‘Balanced Approach’ fall reduction initiative. *Home Health Care Management & Practice* **25**, 224–228.
- Gamage N, Rathnayake N and Alwis G** (2018) Knowledge and perception of falls among community dwelling elderly: a study from southern Sri Lanka. *Current Gerontology and Geriatrics Research* **2018**, 7653469.
- Granberg S** (2015) *Functioning and Disability in Adults with Hearing Loss* (Thesis). Örebro University, Örebro, Sweden.
- Greenberg SA, Sommers MLS, Chittams J and Cacchione PZ** (2016) Measuring fear of falling among high-risk, urban, community-dwelling older adults. *Geriatric Nursing* **37**, 489–495.
- Gu Y and Dennis SM** (2016) Are falls prevention programs effective at reducing the risk factors for falls in people with type-2 diabetes mellitus and peripheral neuropathy: a systematic review with narrative synthesis. *Journal of Diabetes and Its Complications* **31**, 504–516.
- Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB, *et al.*** (1994) A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *Journal of Gerontology* **49**, 85–94.
- Guzzo AS, Meggiolaro A, Mannocci A, Tecca M, Salomone I and La Torre G** (2015) Conley Scale: assessment of a fall risk prevention tool in a general hospital. *Journal of Preventive Medicine and Hygiene* **56**, 77–87.
- Hendrich A, Nyhuis A, Kippenbrock T and Soja ME** (1995) Hospital falls: development of a predictive model for clinical practice. *Nursing Research* **8**, 129–139.
- Higaonna M** (2015) The predictive validity of a modified Japanese Nursing Association fall risk assessment tool: a retrospective cohort study. *International Journal of Nursing Studies* **52**, 1484–1494.
- Higaonna M, Enobi M and Nakamura S** (2017) Development of an evidence-based fall risk assessment tool and evaluation of interrater reliability and nurses’ perceptions of the tool’s clarity and usability. *Japan Journal of Nursing Science* **14**, 146–160.
- Hill K, Vratsidis F, Jessup R, McGann A, Pearce J and Colins T** (2004) Validation of a falls risk assessment tool in the sub-acute hospital setting: a pilot study. *Australasian Journal of Podiatric Medicine* **38**, 99–108.
- Hirase T, Inokuchi S, Matsusaka N, Nakahara K and Okita M** (2014) A modified fall risk assessment tool that is specific to physical function predicts falls in community-dwelling elderly people. *Journal of Geriatric Physical Therapy* **37**, 159–165.
- Hnizdo S, Archuleta RA, Taylor B and Kim SC** (2013) Validity and reliability of the modified John Hopkins Fall Risk Assessment Tool for elderly patients in home health care. *Geriatric Nursing* **34**, 423–427.
- Homer ML, Palmer NP, Fox KP, Armstrong J and Mandl KD** (2017) Predicting falls in people aged 65 years and older from insurance claims. *American Journal of Medicine* **130**, 717–744.
- Horak FB, Wrisley DM and Frank J** (2009) The Balance Evaluation Systems Test (BESTest) to differentiate balance deficits. *Physical Therapy* **89**, 484–498.
- Hung C-H, Wang C-J, Tang T-C, Chen L-Y, Peng L-N, Hsiao F-Y and Chen L-K** (2017) Recurrent falls and its risk factors among older men living in the veterans retirement communities: a cross-sectional study. *Archives of Gerontology and Geriatrics* **70**, 214–218.

- Hur EY, Jin Y, Jin T and Lee S-M** (2016) Longitudinal evaluation of Johns Hopkins Fall Risk Assessment Tool and nurses' experience. *Journal of Nursing Care Quality* **32**, 242–251.
- Jensen DR** (2006) *Medical Model Influence in Counseling and Psychotherapy: Counseling Psychology Training Directors' Views* (ProQuest Dissertations and Theses No. 139). Utah: Brigham Young University.
- Jester R, Wade S and Henderson K** (2005) A pilot investigation of the efficacy of falls risk assessment tools and prevention strategies in an elderly hip fracture population. *Journal of Orthopaedic Nursing* **9**, 27–34.
- Jones CJ, Rikli RE and Beam WC** (1999) A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Research Quarterly for Exercise and Sport* **70**, 113–119.
- Kehinde JO** (2009) Instruments for measuring fall risk in older adults living in long-term care facilities: an integrative review. *Journal of Gerontological Nursing* **35**, 46–55.
- Kenny RA, Romero-Ortuno R and Kumar P** (2016) Falls in older adults. *Medicine in Older Adults* **45**, 28–33.
- Kim T and Xiong S** (2017) Comparison of seven fall risk assessment tools in community-dwelling Korean older women. *Ergonomics* **60**, 421–429.
- Kim EA, Mordiffi SZ, Bee WH, Devi K and Evans D** (2007) Evaluation of three fall-risk assessment tools in an acute care setting. *Journal of Advanced Nursing* **60**, 427–435.
- Kim SR, Yoo S-H, Shin YS, Jeon JY, Kim JY, Kang SJ and An YH** (2013) Comparison of the reliability and validity of fall risk assessment tools in patients with acute neurological disorders. *Korean Journal of Adult Nursing* **25**, 24–32.
- Klenk J, Becker C, Palumbo P, Schwickert L, Rapp K, Helbostad JL and Kerse N** (2017) Conceptualizing a dynamic fall risk model including intrinsic risks and exposures. *Journal of the American Medical Directors Association* **18**, 921–927.
- Klinkenberg W and Potter P** (2017) Validity of the Johns Hopkins fall risk assessment tool for predicting falls on inpatient medicine services. *Journal of Nursing Care Quality* **32**, 108–113.
- LeCuyer M, Lockwood B and Locklin M** (2016) Development of a fall prevention program in the ambulatory surgery setting. *Journal of PeriAnesthesia Nursing* **32**, 472–479.
- Lee Y and Kim S** (2017) Correlation between the fear of falling and fall risk assessment tools in the community-dwelling frail elderly in Korea. *Journal of Clinical Gerontology and Geriatrics* **8**, 123–126.
- Légaré F, Adekpedjou R, Stacey D, Turcotte S, Kryworuchko J, Graham ID and Donner-Banzhoff N** (2018) *Cochrane Database of Systematic Reviews* **7**.
- Lovallo C, Rolandi S, Rossetti AM and Lusignani M** (2010) Accidental falls in hospital inpatients: evaluation of sensitivity and specificity of two risk assessment tools. *Journal of Advanced Nursing* **66**, 690–696.
- Lundin-Olsson L, Jensen J, Nyberg L and Gustafson Y** (2003) Predicting falls in residential care by a risk assessment tool, staff judgement, and history of falls. *Aging Clinical and Experimental Research* **15**, 51–59.
- Lundin-Olsson L, Nyberg L and Gustafson Y** (2006) The Mobility Interaction Fall Chart. *Physiotherapy Research International* **5**, 190–201.
- Ma C, Evans K, Bertmar C and Krause M** (2014) Predictive value of the Royal Melbourne Hospital Falls Risk Assessment Tool (RMH FRAT) for post-stroke patients. *Journal of Clinical Neuroscience* **21**, 607–611.
- Majkusova K and Jarosova D** (2017) Validity of tools for assessing the risk of falls in patients. *Central European Journal of Nursing and Midwifery* **8**, 697–705.
- McDowell I and Newell C** (1996) *Measuring Health: A Guide to Rating Scales and Questionnaires*, 2nd Edn. New York, NY: Oxford University Press.
- McNair DS and Simpson RL** (2016) Bayesian cost-effectiveness analysis of falls risk assessment tools: falls: sensitivity and specificity – asking for decision support changes? *Nursing Administration Quarterly* **40**, 364–369.
- Meyer G, Kopke S, Bender R and Muhlhauser I** (2005) Predicting the risk of falling – efficacy of a risk assessment tool compared to nurses' judgement: a cluster-randomised controlled trial. *BMC Geriatrics* **5**, 14.
- Meyer G, Kopke S, Haastert B and Muhlhauser I** (2009) Comparison of a fall risk assessment tool with nurses' judgement alone: a cluster-randomised controlled trial. *Age and Ageing* **38**, 417–423.
- Miyakoshi K, Nasu T, Takahashi S and Natsume T** (2014) Validation of the Japanese Association of Rehabilitation Medicine Fall Risk Assessment Tool. *Physical Medicine and Rehabilitation* **6**, 130–135.
- Moher D, Liberati A, Tetzlaff J, Altman DG and the PRISMA Group** (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Physical Therapy* **89**, 873–880.
- Moore K, Fearn M, Cyarto E, Renehan E, Haralambous B, Hill K, Robinson A, Nitz J, Haines T, Andrews S, Churchill B and Fu S** (2006) *Star project: an individualized, facilitated and sustainable*

- approach to implementing the evidence in preventing falls in residential aged care facilities. Report to the Australian Government Department of Health and Ageing. Australia: National Ageing Research Institute.
- Morse JM, Morse RM and Tylko SJ** (1989) Development of a scale to identify the fall-prone patient. *Canadian Journal on Aging* **8**, 366–377.
- Narayanan V, Dickinson A, Victor C, Griffiths C and Humphrey D** (2016) Falls screening and assessment tools used in acute mental health settings: a review of policies in England and Wales. *Physiotherapy* **102**, 178–183.
- Noohu MM, Dey AB, Sharma S and Hussain ME** (2017) International classification of function, disability and health framework for fall risk stratification in community dwelling older adults. *Geriatric Care* **3**, 1–7.
- Nunan S, Brown Wilson C, Henwood T and Parker D** (2018) Fall risk assessment tools for use among older adults in long-term care settings: a systematic review of the literature. *Australasian Journal on Ageing* **37**, 23–33.
- Oliver D, Britton M, Seed P, Martin FC and Hopper AH** (1997) Development and evaluation of evidence-based risk assessment tool (STRATIFY) to predict which elderly inpatients will fall: case control and cohort studies. *British Medical Journal* **315**, 1049–1053.
- Ouzzani M, Hammady H, Fedorowicz Z and Elmagarmid A** (2016) Rayyan – a web and mobile app for systematic reviews. *Systematic Reviews* **5**, 210.
- Palumbo P, Palmerini L, Bandinelli S and Chiari L** (2015) Fall risk assessment tools for elderly living in the community: can we do better? *PLOS ONE* **10**, 15–18.
- Palumbo P, Klenk J, Cattelani L, Bandinelli S, Ferrucci L, Rapp K, Chiari L, Rothenbacher D *et al.*** (2016) Predictive performance of a fall risk assessment tool for community-dwelling older people (FRAT-up) in 4 European cohorts. *Journal of the American Medical Directors Association* **17**, 1106–1113.
- Papaioannou A, Parkinson W, Cook R, Ferko N, Coker E and Adachi JD** (2004) Prediction of falls using a risk assessment tool in the acute care setting. *BMC Medicine* **2**, 1.
- Pape H-C, Schemmann U, Foerster J and Knoke M** (2015) The Aachen Falls Prevention Scale – development of a tool for self-assessment of elderly patients at risk for ground-level falls. *Patient Safety in Surgery* **9**, 7–10.
- Park SH** (2017) Tools for assessing fall risk in the elderly: a systematic review and meta-analysis. *Ageing Clinical and Experimental Research* **30**, 1–16.
- Peel N, Bell RAR and Smith K** (2008) *Queensland Stay On Your Feet Community Good Practice Guidelines*. Brisbane, Australia: Queensland Health.
- Phelan EA, Mahoney JE, Voit JC and Stevens JA** (2015) Assessment and management of fall risk in primary care settings. *Medical Clinics of North America* **99**, 281–293.
- Pluijm SM, Smit JH, Tromp EA, Stel VS, Deeg DJ, Bouter LM and Lips P** (2006) A risk profile for identifying community-dwelling elderly with a high risk of recurrent falling: results of a 3-year prospective study. *Osteoporosis International* **17**, 417–425.
- Podsiadlo D and Richardson S** (1991) The timed ‘Up and Go’: a test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society* **39**, 142–148.
- Poe SS, Cvach MM, Gartrell DG, Radzik BR and Joy TL** (2005) An evidence-based approach to fall risk assessment, prevention, and management. Lessons learned. *Journal of Nursing Care Quality* **20**, 107–116.
- Poe SS, Cvach M, Dawson PB, Straus H and Hill EE** (2007) The Johns Hopkins Fall Risk Assessment Tool: postimplementation evaluation. *Journal of Nursing Care Quality* **22**, 293–298.
- Powell LE and Myers AM** (1995) The Activities-specific Balance Confidence (ABC) Scale. *Journals of Gerontology: Biological Sciences and Medical Sciences* **50A**, 28–34.
- Renfro M, Maring J, Bainbridge D and Blair M** (2016) Fall risk among older adult high-risk populations: a review of current screening and assessment tools. *Current Geriatrics Reports* **5**, 160–171.
- Robey-Williams C, Rush KL, Bendyk H, Patton LM, Chamberlain D and Sparks T** (2007) Spartanburg Fall Risk Assessment Tool: a simple three-step process. *Applied Nursing Research* **20**, 86–93.
- Romli MH, Tan MP, Mackenzie L, Lovarini M, Suttanon P and Clemson L** (2017) Falls amongst older people in Southeast Asia: a scoping review. *Public Health* **145**, 6–9.
- Rose DJ, Lucchese N and Wiersma LD** (2006) Development of a multidimensional balance scale for use with functionally independent older adults. *Archives of Physical Medicine and Rehabilitation* **87**, 1478–1485.
- Royal Melbourne Hospital** (1995) Predictive value of the Royal Melbourne Hospital Falls Risk Assessment Tool (RMH FRAT) for post-stroke patients. *Journal of Clinical Neuroscience* **21**, 124–130.

- Rubenstein LZ** (2006) Falls in older people: epidemiology, risk factors and strategies for prevention. *Age and Ageing* 35, 37–41.
- Ruroede K, Pilkington D and Guernon A** (2016) Validation study of the Marianjoy Fall Risk Assessment Tool. *Journal of Nursing Care Quality* 31, 146–152.
- Russell M, Hill K, Dharmage S, Blackberry I and Day L** (2006) Evaluation of the Falls Risk for Older People in the Community (FROP-Com) Assessment Tool. *Australasian Epidemiologist* 13, 53.
- Russell MA, Hill KD, Blackberry I, Day LM and Dharmage SC** (2008) The reliability and predictive accuracy of the falls risk for older people in the community assessment (FROP-Com) tool. *Age and Ageing* 37, 634–639.
- Salb J, Finlayson J, Almutaseb S, Scharfenberg B, Becker C, Sieber C and Freiberger E** (2015) Test–retest reliability and agreement of physical fall risk assessment tools in adults with intellectual disabilities. *Journal of Intellectual Disability Research* 59, 1121–1129.
- Schmid NA** (1990) Reducing patient falls: a research-based comprehensive fall prevention program. *Military Medicine* 155, 202–207.
- Scott V, Votova K, Scanlan A and Close J** (2007) Multifactorial and functional mobility assessment tools for fall risk among older adults in community, home-support, long-term and acute care settings. *Age and Ageing* 36, 130–139.
- Selb M, Escorpizo R, Kostanjsek N, Stucki G, Ustun B and Cieza A** (2015) A guide on how to develop an International Classification of Functioning, Disability and Health Core Set. *European Journal of Physical and Rehabilitation Medicine* 51, 105–117.
- Seneviratne C** (2006) The STRATIFY falls risk assessment tool was not useful in predicting falls in patients with acute stroke. *Evidence-based Nursing* 9, 91.
- Skelton KW, Papanek PE, Lynch SB and Ryan PA** (2014) Fall incidence and self-reported health in middle aged women: need for new risk assessment tools. *Medicine & Science in Sports & Exercise* 46, 431.
- Stapleton C, Hough P, Oldmeadow L, Bull K, Hill K and Greenwood K** (2009) Four-item fall risk screening tool for sub-acute and residential aged care: The first step in fall prevention. *Australasian Journal on Ageing* 28, 139–143.
- Stewart Williams J, Kowal P, Hestekin H, O'Driscoll T, Peltzer K, Yawson A and Chatterji S** (2015) Prevalence, risk factors and disability associated with fall-related injury in older adults in low- and middle-income countries: results from the WHO Study on Global Ageing and adult health (SAGE). *BMC Medicine* 13.
- Stretanski M, Lusardi M, Dumont L and Evans L** (2002) Predicting risk of future falls among residents of health care facilities: Berg Balance Scale and Fall Risk Assessment Tool. *Journal of Geriatric Physical Therapy* 25, 22.
- Teh RC, Wilson A, Ranasinghe D and Visvanathan R** (2017) Use and clinical efficacy of standard and health information technology fall risk assessment tools. *Australasian Journal on Ageing* 36, 327–331.
- Thiamwong L, Thamarpirat J, Maneesriwongul W and Jitapunkul S** (2009) Thai Falls Risk Assessment Test (Thai-FRAT) developed for community-dwelling Thai elderly. *Journal of the Medical Association of Thailand* 91, 1823–1831.
- Tiedemann A** (2006) *The development of a validated falls risk assessment for use in clinical practice*. Australia: University of New South Wales.
- Tiedemann A, Lord S and Sherrington C** (2012) The Quickscreen tool: a validated falls risk assessment, developed and implemented in Australia for use in primary care. *Injury Prevention* 18, 38–56.
- Tinetti ME, Williams TF and Mayewski R** (1986) Fall risk index for elderly patients based on number of chronic disabilities. *American Journal of Medicine* 80, 429–434.
- Van Swearingen JM, Paschal KA, Bonino P and Yang JF** (1996) The modified Gait Abnormality Rating Scale for recognizing the risk of recurrent falls in community-dwelling elderly adults. *Physical Therapy* 76, 994–1002.
- Vassallo M, Stockdale R, Sharma JC, Briggs R and Allen S** (2005) A comparative study of the use of four fall risk assessment tools on acute medical wards: a comparison of four falls risk assessment tools. *Journal of the American Geriatrics Society* 53, 1034–1038.
- Vassallo M, Poynter L, Sharma JC, Kwan J and Allen SC** (2008) Fall risk-assessment tools compared with clinical judgment: an evaluation in a rehabilitation ward. *Age and Ageing* 37, 277–281.

- Vergheze J, Buschke H, Viola L, Katz M, Hall C, Kuslansky G and Lipton R** (2002) Validity of divided attention tasks in predicting falls in older individuals: a preliminary study. *Journal of the American Geriatrics Society* **50**, 1572–1576.
- Western Australia Department of Health** (2015) *Development of Falls Risk Assessment and Management Plan*. Perth: Health Strategy. Western Australia Department of Health.
- Whitney SL, Wrisley DM, Marchetti GM, Gee MA, Redfern MS and Furman JM** (2005) Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the Five-Times-Sit-to-Stand Test. *Physical Therapy* **85**, 1034–1045.
- Wildes TM, Dua P, Fowler SA, Miller JP, Carpenter CR, Avidan MS and Stark S** (2015) Systematic review of falls in older adults with cancer. *Journal of Geriatric Oncology* **6**, 70–83.
- Wong Shee A, Phillips B and Hill K** (2012) Comparison of two fall risk assessment tools (FRATs) targeting falls prevention in sub-acute care. *Archives of Gerontology and Geriatrics* **55**, 653–659.
- World Health Organization** (2002) *Towards a Common Language for Functioning, Disability and Health: ICF*. WHO/EIP/GPE/CAS/01.3. Geneva: World Health Organization.
- World Health Organization** (2018) *Fact Sheet: Falls*. Geneva: World Health Organization. Available at <http://apps.who.int/mediacentre/factsheets/fs344/en/index.html>.
- Yamashita Y, Kogo H, Kawaguchi N, Toriyama H and Mizota K** (2016) Usefulness of occlusal force measurement as a fall risk assessment tool. *Rigakuryoho Kagaku* **31**, 303–307.
- Yardley L, Beyer N, Hauer K, Kempen G, Piot-Ziegler C and Todd C** (2005) Development and initial validation of the Falls Efficacy Scale-International (FES-I). *Age and Ageing* **34**, 614–619.
- Young D, Liaw S-T and Sulaiman N** (2005) Falls risk assessment and management system (FRAMS) – a decision support tool developed for general practitioners and their primary care team. *Hong Kong Practitioner* **27**, 306–311.
- Zhang X and Lockhart TE** (2009) A reliability study of three functional mobility assessment tools in fall risk evaluation. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* **53**, 1719–1723.
- Zhang J, Wang M and Liu Y** (2016) Psychometric validation of the Chinese version of the Johns Hopkins Fall Risk Assessment Tool for older Chinese inpatients. *Journal of Clinical Nursing* **25**, 19–20.
- Zur O, Shaki T and Carmeli E** (2016) Concurrent validity and reliability of a new balance scale used in older adults. *Advances in Experimental Medicine and Biology* **910**, 63–70.