Towards enhanced management of fear of falling in older people

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Unravelling interventions and measuring related avoidance of activity

Marlot Kruisbrink

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Chapter 1: General introduction

Ageing society and fear of falling

All around the world, populations are ageing. The percentage of people aged 65 years or over is projected to rise from 12% in 2015 to 22% in 2050 (World Health Organization, 2018). This will increase healthcare costs and pressure on healthcare systems (World Health Organization, 2011). Additionally, in many countries, staff shortages create difficulties in dealing with increased care demands (American Association of Colleges of Nursing, 2020; Buerhaus et al., 2017; Juraschek et al., 2012; Panteia, 2020; World Health Organization, 2016). In order to keep healthcare affordable and reduce pressure on healthcare systems, it is essential that people remain capable of independently performing daily activities and that disability from health conditions is reduced (Maarse & Jeurissen, 2016). One of the major causes of disability in old age is falling. In the Netherlands, one third of older adults fall at least once each year (VeiligheidNL, 2019). Falls are the biggest cause of emergency department visits among older adults and the direct costs of falls accounted for 1% of total health care costs in 2019 (VeiligheidNL, 2019). Next to the physical and cost-related aspects of falls, the psychological aspects are of interest as well. The fear of falling (FoF) is even more prevalent than falls and also contributes to disability and early admission to nursing homes (Cumming et al., 2000). In the Netherlands, about half of older community-dwelling adults are afraid to fall (Halfens et al., 2016; Zijlstra et al., 2007). Worldwide, prevalence rates typically range between 21 and 85% (Makino et al., 2017; Malini et al., 2016; Scheffer et al., 2008; Tomita et al., 2018), depending on the exact population under study and the definition that is used.

What is fear of falling?

Historically, different constructs for the psychological aspects of falls have been used and they have been defined in various ways. First, terms such as ptophobia or post-fall syndrome were used to describe the intense fear and phobic behavior that could develop after a fall (Bhala et al., 1982; Murphy & Isaacs, 1982). Patients were afraid of standing or walking, even if there was physically no reason to (Bhala et al., 1982). In 1990, one of the first questionnaires specifically developed for the construct FoF was published: the Falls Efficacy Scale (FES). The FES conceptualized FoF as “low perceived self-efficacy at

avoiding falls during essential non-hazardous activities of daily living" (Tinetti et al., 1990). In 1993, Tinetti and Powell defined FoF as "a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing" (Tinetti & Powell, 1993). After this, scales for psychological constructs such as worry about falling and balance confidence were introduced (Lachman et al., 1998; Powell & Myers, 1995). These terms were commonly placed under FoF as well and FoF became an umbrella term for psychological aspects of falls, including both cognitive-based constructs (e.g. balance confidence or fall-related self-efficacy) and affect-based constructs (e.g. concern or worry about falling) (Greenberg, 2012; Hadjistavropoulos et al., 2011; Jørstad et al., 2005; Moore & Ellis, 2008; Scheffer et al., 2008).

Authors choose a conceptualization and operationalization of FoF, depending on the specific goals of their research and the population under study. In this thesis, both the term FoF and concerns about falling (CaF) are applied. When literature is reviewed or discussed, the umbrella term FoF is used. The term CaF is used in the sections that refer to an intervention or measurement instrument developed specifically for CaF.

Causes and consequences of fear of falling

Falls are a risk factor for developing FoF (Lach, 2005; Uemura et al., 2015). However, FoF also occurs without having recently experienced a fall (Halfens et al., 2016; Makino et al., 2017; Zijlstra et al., 2007). In the Netherlands, 44% of community-dwelling older adults that have not fallen in the past six months are afraid to fall (Zijlstra et al., 2007). This indicates that falls may not be the sole cause of FoF. Although findings are often inconsistent, many variables have been associated with FoF (Denkinger et al., 2015). For example, physical and mental health issues, such as visual impairment, poor self-perceived health, cognitive impairment, balance problems, anxiety and depression may play a role (Denkinger et al., 2015; Hull et al., 2013; Kempen et al., 2009; Lach, 2005; Murphy et al., 2003; Oh-Park et al., 2011; Scheffer et al., 2008; Uemura et al., 2015). Furthermore, the neighborhood environment is associated with FoF (Curl et al., 2020; Lee et al., 2018). Social factors, such as lack of support or social isolation could also be risk factors (Filiatrault et al., 2009; Howland et al., 1998; Murphy et al., 2003; Reyes-Ortiz et al., 2006).

Consequences of FoF are serious and varied as well. They include activity avoidance, decreased physical functioning, falls, social isolation, reduced quality of life and early nursing home admission (Cumming et al., 2000; Delbaere et al., 2004; Meulen et al., 2014). FoF can be considered a protective response to prevent falls. However, it may arise from a perceived mismatch between a person's abilities and the situation, and could lead to excessive avoidance of activities that one remains capable of performing (Delbaere et al., 2010; Lim et al., 2018). Given its serious consequences, intervention can be required.

Themes addressed in this thesis

A variety of intervention strategies can be used to manage FoF. These can address the physical, psychological, environmental and social causes of FoF. However, many interventions reach small to moderate effect sizes in trials (Büla et al., 2011; Chua et al., 2019; Kendrick et al., 2014). New, more effective interventions should be developed or existing interventions should be improved, to improve quality of life of older adults and reduce the waste of resources. This raises the question which factors are actually contributing towards intervention effects on FoF. In Part 1 of this thesis, factors that may be important for intervention optimization are investigated.

Subsequently, the behavioral consequences of FoF will be addressed. Avoidance of activities due to FoF is understudied, even though it is associated with several negative outcomes and prevalences as high as 58% have been reported among community-dwelling older adults who have fallen (Zijlstra et al., 2007). There is not yet a widely used instrument for avoidance behavior due to FoF. Part 2 of this thesis relates to the evaluation of the Falls Efficacy Scale – International Avoidance Behavior (FES-IAB): a new measure of activity avoidance due to CaF.

Part 1: Unravelling interventions

Interventions for fear of falling

Many previous studies have investigated the effects of interventions on FoF. From these studies, it becomes evident that different types of interventions can be effective in reducing FoF, such as exercise interventions, cognitive behavioral interventions and occupational therapy (Chua et al., 2019; De Coninck et al.,

2017; Kendrick et al., 2014). However, the effects are small to moderate and there may be room to optimize interventions. In order to increase effects of interventions, it is important to determine what contributes to the effects.

The content of an intervention is an obvious factor that influences effects. For example, in a review by Kendrick and colleagues (Kendrick et al., 2014), strength exercise reached a non-significant trivial effect (standardized mean difference: 0.08 (95% CI: -0.18; 0.34), while 3D exercise reached a significant moderate to large effect (standardized mean difference 0.60 (95% CI: 0.09; 1.12). However, there is also variation in effects within similar interventions, i.e. within interventions of the same intervention type. For example, in the study by Kendrick et al., there was great variation in the effect sizes of the individual strength exercise studies, with standardized mean differences ranging from -0.12 to 0.94. This indicates that there could be more factors than intervention content that contribute to effectiveness.

Factors that influence intervention effects

Several theories and guidelines about interventions and intervention research exist, such as Intervention Mapping, the Behavior Change Wheel, CONSORT statement and MRC framework (Craig et al., 2008; Eldredge et al., 2016; Michie et al., 2014; Schulz et al., 2010; Skivington et al., 2021). They describe how to develop, implement, evaluate and report on interventions, and they contain an abundance of information on what factors could contribute to effects. These factors are summarized in the Template for Intervention Description and Replication (TIDieR) checklist (Campbell et al., 2018; Hoffmann et al., 2014). This checklist describes how not only intervention *content* (i.e. *what is delivered*), but also other intervention *characteristics* such as *how, where, how much* and *when* should be reported. Indeed, intervention content can be delivered in different formats (e.g. alone or in a group) and by different methods (e.g. telephone or internet). Furthermore, interventions may be delivered in different settings (e.g. at home or somewhere in the community) and the dose or intensity can vary. The duration of interventions, and the schedule by which intervention content is delivered can also differ. Previous research indicated that these intervention characteristics have the potential to influence intervention effects. For example, it has been demonstrated that the delivery method is a significant moderator of

interventions aiming to increase physical activity behavior in older adults (Chase, 2015). Interventions that were delivered through audio-visual media or with mailed materials were more effective than interventions that did not use these delivery methods.

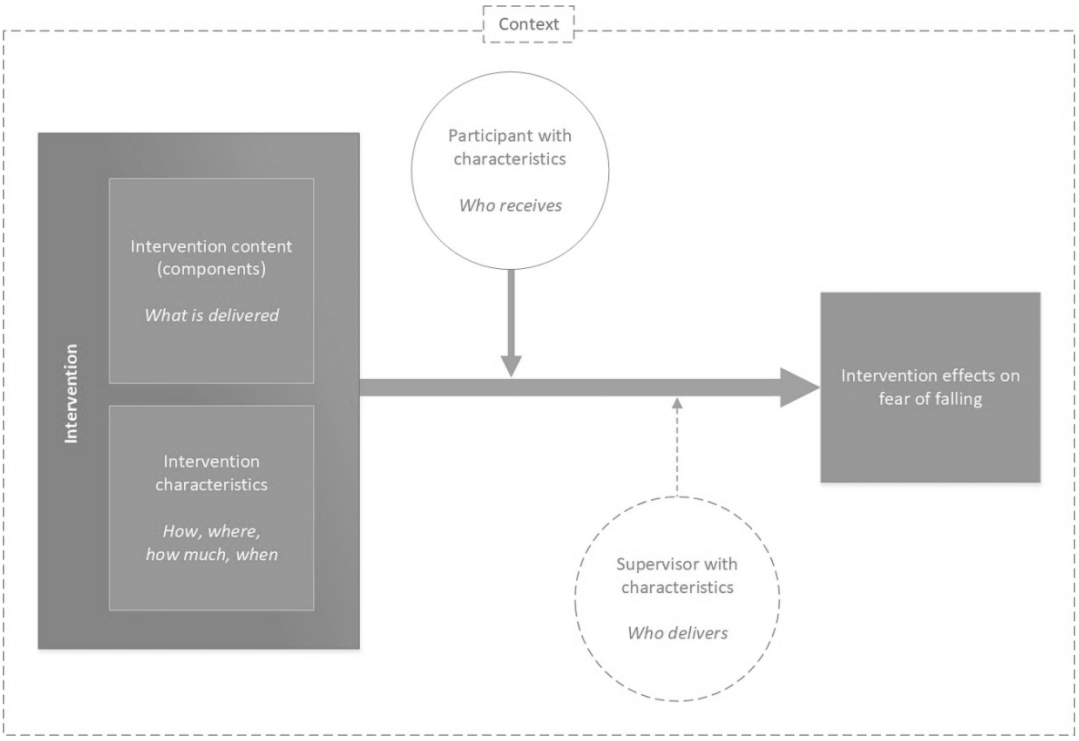

Figure 1. Schematic overview of factors that may influence intervention effects on fear of falling.

The intervention characteristics mentioned above are schematically visualized in Figure 1. Together with the intervention content, the intervention characteristics make up the intervention, that is delivered within a certain context. The intervention can reach an effect on FoF, which is visualized by the arrow. Figure 1 also contains two circles with other people-related factors that may influence the intervention effects: participants (in this thesis: community-dwelling older adults) and intervention supervisors. Participants themselves possess characteristics that can influence effects. The planning approaches Intervention mapping (Eldredge et al., 2016) and the Behavior Change Wheel (Michie et al., 2014) emphasize that participants' characteristics (e.g., their levels of knowledge and motivation) influence their possibilities to actively

engage in the intervention. *Who receives* may therefore also be an important factor (Hoffmann et al., 2014). Furthermore, an extra actor – the supervisor – can be involved in delivering interventions to participants. Since not all interventions are supervised, a dotted line surrounds this factor in Figure 1. The TIDieR checklist mentions *who provided*, referring to the expertise, training and background of the intervention provider or supervisor (Hoffmann et al., 2014). As these characteristics may influence the supervisors' ability to optimally deliver an intervention, it makes sense that they may influence intervention effects. Participants may also be able to identify themselves more with some supervisors than with others. Previous studies have demonstrated that supervisor characteristics can influence effects. For example, Lacroix and colleagues found different effects on balance for supervised and unsupervised interventions (Lacroix et al., 2016) and Pighills and colleagues found different effects on falls for different types of supervisors (Pighills et al., 2011).

Thus far, studies have investigated a limited range of intervention characteristics regarding their effects on FoF, such as the setting (e.g. at home or in the community), format (e.g. group or individual), and duration. Characteristics such as the type of supervisor and delivery method are usually not taken into account. Furthermore, investigations have been limited to one type of intervention, e.g. the influence of the setting for only strength training. Hence, the scientific literature currently contains no overview of all types of interventions, their characteristics and their effects. Furthermore, it is unknown whether there are intervention characteristics that have overarching effects, i.e. whether interventions for FoF should always possess certain characteristics to be effective. Lastly, Figure 1 mentions components in the intervention content box. Classifying interventions into intervention types according to their most prominent feature, such as an 'education' intervention, may be problematic. Within intervention types, there is still a range of different intervention components. For example, an education intervention can contain education on different subjects, and may contain components such as discussion and social comparison between participants. Furthermore, education interventions may also contain components unrelated to education, such as feedback or referral to other services. By analyzing interventions based on intervention type alone, previous investigations have ignored the variety of intervention components

that is nearly always present. There is currently no detailed information on what intervention components may influence effects on FoF.

Approach

By exploring the characteristics and components visualized in Figure 1, clues may emerge on how to optimize interventions. Several approaches can be taken to collect evidence on these factors. The randomized controlled trial (RCT) has long been considered as the golden standard for testing effects. However, traditional RCTs do not provide information about which characteristics and components are contributing towards the effect (Collins et al., 2007). RCTs with multiple arms can be used to study a limited number of factors. Furthermore, due to the costs and effort associated with conducting an RCT, RCTs are ideally conducted when there is already a good idea of promising intervention characteristics and components. Candidate characteristics and components are preferably identified with other methodologies. One possibility is to study published literature. Meta-analysis is suitable to investigate many of the characteristics mentioned above in a single study. Effects on FoF and factors such as the delivery method, format, presence of supervision, and intervention components may be reported in published studies about interventions. Another possibility is secondary data analysis, which can provide valuable insights on a more detailed scale. As a dataset of a RCT contains data on individual participants, it is very suitable to investigate the impact of the characteristics of participants on intervention outcomes.

A potential candidate intervention to investigate with secondary data analysis is A Matter of Balance (AMB) (Tennstedt et al., 1998). AMB was initially developed in the United States of America, specifically for older people with CaF and activity restriction. The eight-week cognitive behavioral group intervention uses techniques such as goal setting and restructuring misconceptions to reduce CaF. By now, it has demonstrated effectiveness internationally and it has been successfully adapted to the Dutch setting into the intervention A Matter of Balance - Netherlands (AMB-NL) (Zijlstra et al., 2009). An effective individual version of this intervention, to be delivered at home, has been developed as well (AMB-Home) (Dorresteijn et al., 2016). AMB-NL and AMB-Home are also both cost-effective and feasible (Dorresteijn et al., 2013; Evers et al., 2020; van

Haastregt et al., 2013; van Haastregt et al., 2007). Furthermore, they achieve effects on other outcomes, such as activity restriction and symptoms of depression, and the effect sizes for CaF are small to moderate, indicating there is still room for improvement. Thus, AMB-NL and AMB-Home are appropriate interventions to study how participant characteristics influence effects.

In short, Part 1 of this thesis will explore various factors that may influence intervention effects on FoF using meta-analysis and secondary data-analysis.

Part 2: Measuring activity avoidance due to fear of falling

Research on activity avoidance due to fear of falling

Falls have been a topic of research for decades. Figure 2 gives a rough indication of how, more recently, the FoF has gained momentum in research (also see Appendix A). Thus far, behavioral consequences of FoF are lagging behind. Activity avoidance due to FoF – sometimes called activity limitation, activity restriction or avoidance behavior – is reported by 75% of older adults who have FoF (Deshpande et al., 2008). The traditional fear-avoidance model describes how falls lead to FoF, which in turn causes avoidance of activities. Consequently, this results in physical deconditioning, which leads to more falls, fear and avoidance (Brummel-Smith, 1989; Hadjistavropoulos et al., 2011). In reality, the relationship between falls, FoF and activity avoidance may be much more complex and a multifactorial causation model may be more accurate (Büla et al., 2011; Hadjistavropoulos et al., 2011; Peeters et al., 2020). If more studies in the field of falls would include a measure of activity avoidance due to FoF, this would facilitate the study of associations and underlying causal mechanisms. In addition, moderate and severe activity restriction due to FoF predict IADL disability and a decline in physical functioning independently from FoF (Deshpande et al., 2008). Furthermore, activity avoidance may be predictive of future falls (Delbaere et al., 2004; Landers et al., 2016). Hence, activity avoidance due to FoF is an important outcome to assess in its own right. Yet, few studies actually take it into account.

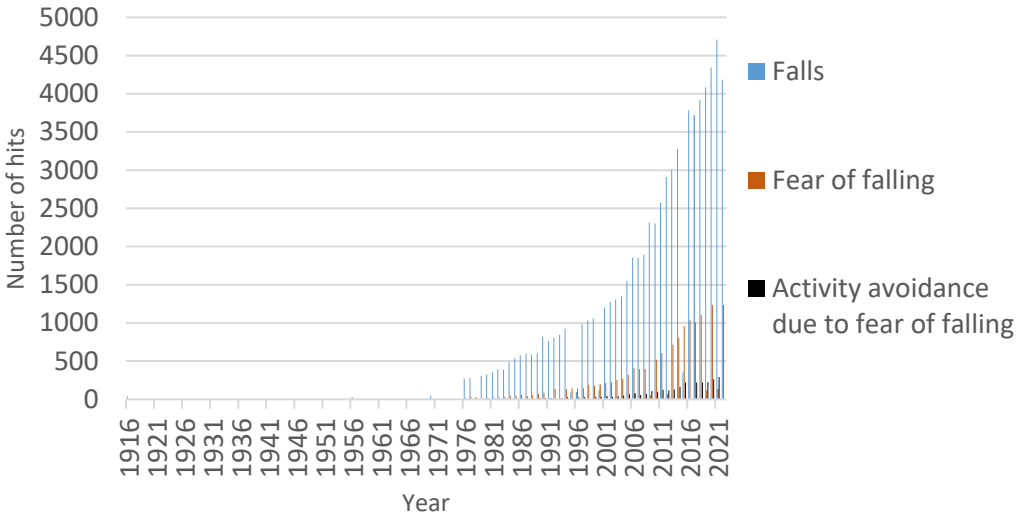

Figure 2 . Number of PubMed results on falls, fear of falling and activity avoidance due to fear of falling. The search strategy on which this figure is based can be viewed in the appendix of this chapter.

Measurement of activity avoidance due to fear of falling

A first step towards addressing the paucity of research is the development of an instrument that can measure activity avoidance due to FoF efficiently and can be routinely administered as part of RCTs and other studies. Several instruments have been developed to assess activity avoidance due to FoF, such as The Survey of Activities and Fear of Falling in the Elderly (SAFFE) (Lachman et al., 1998) and the Fear of Falling Avoidance Behavior Questionnaire (FFABQ) (Landers et al., 2011). These instruments have demonstrated adequate psychometric properties (Acaröz Candan et al., 2020; Hotchkiss et al., 2004; Jonasson et al., 2014; Lachman et al., 1998; Landers et al., 2011; Liu & Ng, 2019; Nilsson et al., 2010; Talley et al., 2008; Yardley & Smith, 2002). However, the available instruments are not yet routinely administered, because their administration takes a substantial amount of time and causes additional burden. A potential solution is adding a measure of activity avoidance to an existing widely used measure of FoF.

In 2005, the Falls Efficacy Scale – International (FES-I) was developed to measure CaF. The FES-I contains 16 items that assess the level of CaF when carrying out activities. The items describe a variety of in- and outdoor activities,

making it applicable for populations that vary in their physical functioning (Kempen et al., 2007; Yardley et al., 2005). The FES-I has consistently demonstrated good psychometric properties (Kempen et al., 2007; Yardley et al., 2005). A validated short version, the 7-item Short FES-I, is also available (Kempen et al., 2008). The database of translated FES-I questionnaires now amounts to over 40 translations (Prevention of Falls Network Europe, n.d.). In short, the FES-I has quickly become the international standard to measure CaF.

The FES-I Avoidance Behavior (FES-IAB) was developed by Dorresteijn and colleagues (Dorresteijn et al., 2016). For each item in the FES-I, people are also asked to what extent they avoid the activity due to their CaF. As an extension of the widely used FES-I, the FES-IAB can increase data collection efficiency, decrease participant burden, and facilitate comparison between studies. The second part of this thesis evaluates the psychometric properties of the FES-IAB.

Aims

In order to manage FoF, effective interventions are necessary. However, interventions often reach small to moderate effects. In order to optimize interventions, it is helpful to identify factors that could contribute to a decrease in FoF. Thus, the objectives of the first part of this thesis are:

- To explore which overarching characteristics of interventions are effective in reducing FoF in community-dwelling older people. (Chapter 2)
- To explore the association between specific intervention components and the reduction of FoF among community-dwelling older people. (Chapter 3)
- To explore whether the effects of cognitive behavioral interventions for CaF in community-dwelling older people differ according to participant characteristics, i.e. whether participant characteristics are moderators of the intervention effect. (Chapter 4)

The second part of the thesis concerns activity avoidance due to FoF. Activity avoidance due to FoF is currently understudied and an efficient measurement instrument that can be administered in combination with internationally accepted FES-I is lacking. Therefore, the objective of this part is:

- To assess the psychometric properties of the FES-IAB and shortened FES-IAB in community-dwelling older people. (Chapter 5)

Outline

Chapter 2 presents the results of a systematic review of interventions with FoF as an outcome. The association between intervention effects and intervention characteristics are investigated with meta-regression. *Chapter 3* reports on an update of the review in Chapter 2. This chapter zooms in on the content of interventions, by providing a detailed overview of what intervention components are available and how they are associated with intervention effects. In Chapter 2 and 3, a broad definition of FoF is used, including affective and cognitive conceptualizations. In *Chapter 4*, we analyze data of two effective interventions specifically designed for CaF and related activity avoidance. We study characteristics of participants and their influence on the effects of cognitive behavioral interventions. *Chapter 5* focusses on the evaluation of the Falls Efficacy Scale – International Avoidance Behavior (FES-IAB) in a sample of participants of an online panel. Finally, *Chapter 6* comprises a summary and discussion of all studies. Furthermore, it includes implications for clinical practice and future research.

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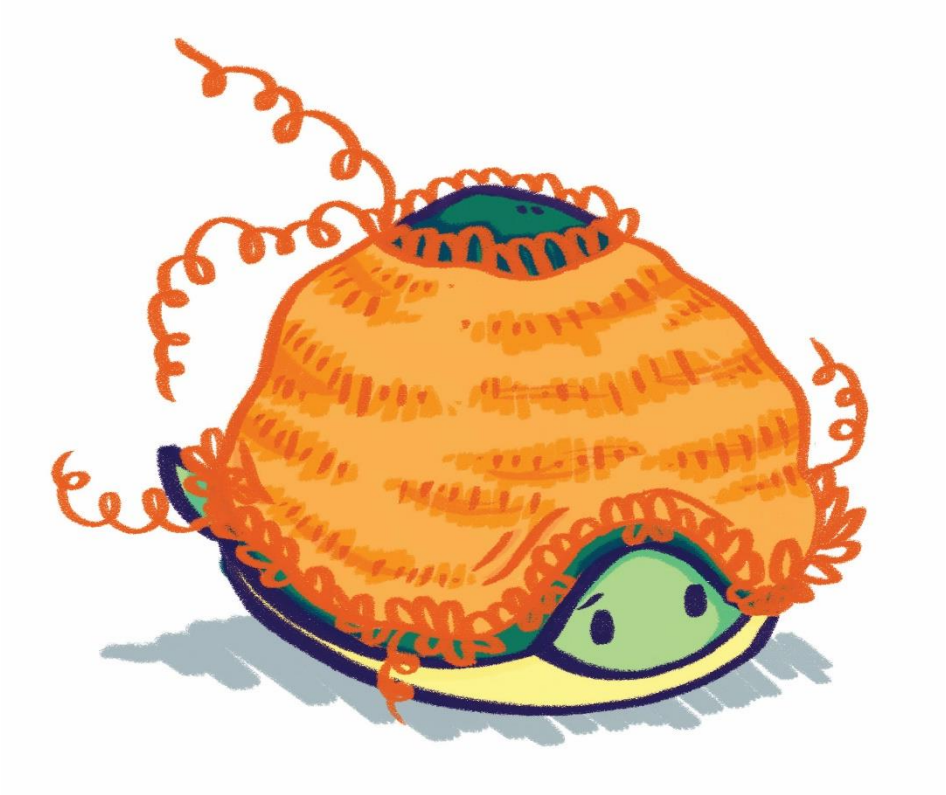
Appendix A - Search queries that support Figure 2

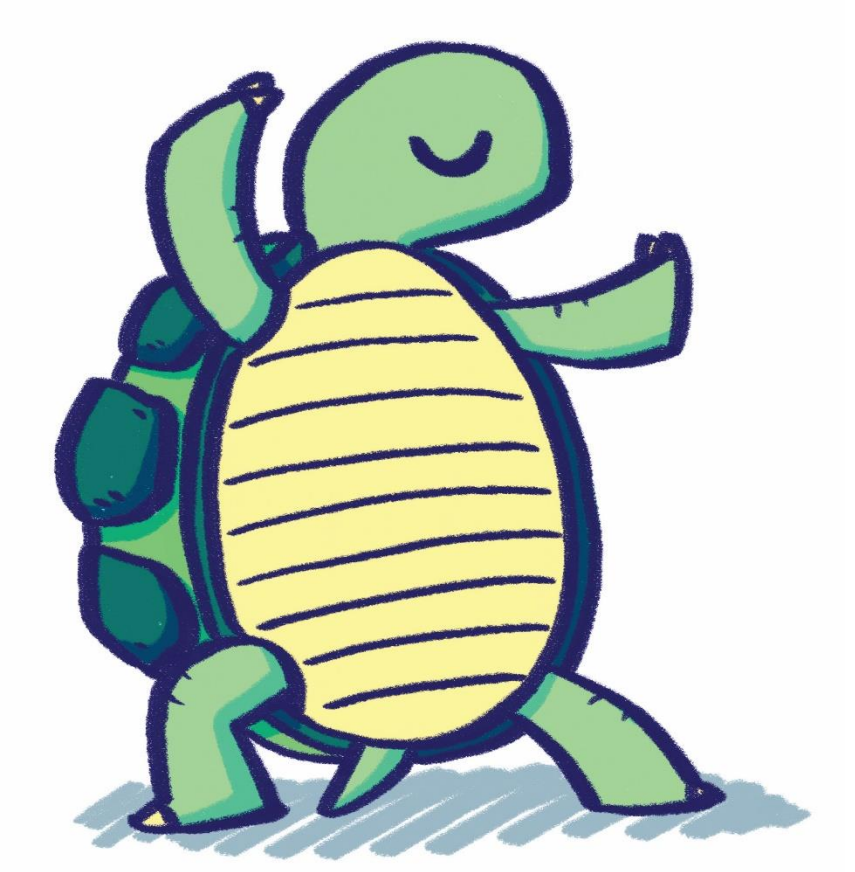
Searches were performed on 27-11-2021 in PubMed.

1: Aged [MeSH] OR Geriatrics [MeSH]
2: elder* [tiab] OR geriatri* [tiab] OR senior* [tiab] OR retire* [tiab]
3: old [tiab] OR older [tiab] OR oldest [tiab]
4: age [tiab] OR aged [tiab] OR old [tiab] OR older [tiab] OR oldest [tiab] OR very [tiab] OR people [tiab] OR person* [tiab] OR subject* [tiab] OR patient* [tiab] OR adult* [tiab] OR men [tiab] OR women [tiab] OR female* [tiab] OR male* [tiab] OR population* [tiab]
5: year* [tiab] AND (65 [tiab] OR 70 [tiab] OR 75 [tiab] OR 80 [tiab])
6: #1 OR #2 OR (#3 AND #4) OR #5
7: Accidental Falls [Mesh] OR fall* [tiab]
8: Fear [Mesh] OR Anxiety [Mesh] OR Phobia [Mesh] OR self efficacy [mesh] OR fear [Tiab] OR anxiety [Tiab] OR phobi* [tiab] OR efficacy [Tiab] OR threat* [Tiab] OR concern* [Tiab] OR confidence [Tiab] OR confident [tiab] OR afraid [Tiab] OR worry [Tiab] OR worries [Tiab] OR worrying [tiab] OR consequence* [Tiab] OR psychosocial [tiab] OR psychological [tiab]
9: activities of daily living [mesh] OR movement [MeSH] OR activit* [Tiab] OR active* [tiab] OR exercis* [Tiab] OR physical [tiab] OR move* [Tiab] OR mobility [tiab] OR action* [Tiab] OR social [tiab] OR ADL [tiab] OR behav* [tiab] OR participat* [tiab]
10: Avoidance Learning [Mesh] OR avoid* [tiab] OR restrict* [tiab] OR decreas* [tiab] OR evasion [tiab] OR evad* [tiab] OR restrain* [tiab] OR limit* [tiab] OR barrier* [tiab]

Falls: #6 AND #7
Fear of falling (including affective and cognitive conceptualizations): #6 AND #7 AND #8
Activity avoidance due to fear of falling: #6 AND #7 AND #8 AND #9 AND #10



Part 1
Unravelling interventions



Chapter 2: Intervention characteristics associated with a reduction in fear of falling among community-dwelling older people: A systematic review and meta-analysis of randomized controlled trials

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Abstract

Background and objectives: Fear of Falling (FoF) is associated with decreased physical functioning and an increased fall risk. Interventions generally demonstrate moderate effects and optimized interventions are needed. Intervention characteristics, such as setting or delivery method may vary. We investigated which overarching intervention characteristics are associated with a reduction in FoF in community-dwelling older people.

Research design and methods: A systematic review and meta-analysis of randomized controlled trials (RCTs) in community-dwelling older people without specific diseases was performed. Associations between intervention characteristics and Standardized Mean Differences (SMD) were determined by univariate meta-regression. Sensitivity analyses were performed.

Results: Data on 62 RCTs was extracted, 50 intervention groups were included in the meta-analysis. Most intervention characteristics and intervention types were not associated with the intervention effect. Supervision by a Tai Chi instructor (B: -1.047. 95%CI: -1.598; -0.496) and delivery in a community setting (B: -0.528. 95%CI: -0.894; -0.161) were - compared to interventions without these characteristics - associated with a greater reduction in FoF. Holistic exercise, such as Pilates or yoga, (B: -0.823. 95%CI: -1.255; -0.392), was also associated with a greater reduction in FoF. Delivery at home (B: 0.384. 95%CI: 0.002; 0.766) or with written materials (B: 0.452. 95%CI: 0.088; 0.815) and tailoring (B: 0.687. 95%CI: 0.364; 1.011) were less effective in reducing FoF.

Discussion and implications: Holistic exercise, delivery with written materials, the setting and tailoring potentially represent characteristics to take into account when designing and improving interventions for FoF in community-dwelling older people.

PROSPERO international prospective register of systematic reviews, registration ID CRD42018080483.

Keywords: accidental falls, intervention effectiveness, falls self-efficacy

Introduction

Falls are a major cause of morbidity and mortality among older people and they account for a large share of health care costs (World Health Organisation, 2018). Up to 90% of all fractures result from a fall and in the Netherlands, for example, injurious falls constitute 41% of costs related to home and leisure injuries (Peeters et al., 2009; Polinder et al., 2016). In addition, falls can have psychological consequences, such as fear of falling (FoF). Historically, FoF has been used to refer to cognitive constructs (e.g. balance confidence or fall-related self-efficacy) and affect-based constructs (e.g. concern or worry about falling). FoF is common among older people. Depending on the population and measure, prevalence rates vary between 21% and 85% (Malini et al., 2016; Scheffer et al., 2008; Tomita et al., 2018). It also occurs in those who have not previously fallen (Scheffer et al., 2008). Consequences of FoF include avoidance of activities, decreased physical functioning, an increased risk of falls, and lower social participation and it represents a problem for independence and independent living (Scheffer et al., 2008; van der Meulen et al., 2014; Yardley & Smith, 2002). Given these consequences, FoF is a public health problem that requires attention and effective interventions to reduce FoF in community-dwelling older people are necessary.

Different types of interventions, such as Tai Chi, active video games and cognitive behavioral therapy (CBT) (Liu & Frank, 2010; Liu et al., 2018; Taylor et al., 2016), have already demonstrated reductions in FoF in older people. Studies show that effects do not only vary between types of interventions, but can also vary within intervention types. For example, Logghe et al. (2009) reported a Tai Chi Chuan intervention had no effects on FoF while Zhang, Ishikawa-Takata, Yamazaki, Morita, & Ohta (2006) demonstrated a Tai Chi Chuan intervention caused a significant reduction in FoF. This variation in intervention effects may be partly explained by differences in content, e.g. 24 Tai Chi positions were used in the study by Zhang et al. (2006), while only 10 were used in the study by Logghe et al. (2009). However, according to Peters, de Bruin and Crutzen (2015) and Mahoney (2010), the effectiveness of interventions can also be determined by other characteristics, such as how the intervention content is delivered and to whom. Several reviews and meta-analyses have been performed to identify characteristics that could be contributing to the effectiveness of FoF

interventions in community-dwelling older people. For instance, Liu et al. (2018)and Kendrick et al. (2014) studied the effectiveness of interventions in relation to the group format, i.e. interventions delivered in groups or individually. Liu et al. (2018) showed a small effect for group CBT interventions (n=4) and a small to moderate effect for individual CBT interventions (n=2). Kendrick et al. (2014) studied the effect of exercise interventions and found no difference between group and individual interventions in a meta-analysis of 24 studies. Other characteristics often studied in reviews and meta-analyses are duration of the intervention (Büla et al., 2011; Kendrick et al., 2014; Liu et al., 2018; Whipple et al., 2017), frequency or number of intervention sessions (Kendrick et al., 2014; Liu et al., 2018; Logghe et al., 2010) and location (Jung et al., 2009; Logghe et al., 2010).

Despite the existence of several reviews on the subject of intervention characteristics, characteristics like tailoring, type of supervisor and delivery method (e.g. face-to-face, telephone or internet) are frequently not taken into account. Moreover, reviews assessing intervention characteristics are often limited to one type of intervention, e.g. only video games or strength training, or include only a small number of trials (Dennett & Taylor, 2015; Fisseha et al., 2017; Jung et al., 2009; Liu et al., 2018; Logghe et al., 2010; Neri et al., 2017; Rodrigues et al., 2014; Wong et al., 2017). Consequently, a patchwork of information and recommendations emerges. The current knowledge base lacks an overview of all types of interventions and insight into overarching effective intervention characteristics. Furthermore, small to moderate effect sizes may be an indication that optimization of FoF interventions is possible. Presumably, effect sizes could increase by strengthening effective characteristics and removing or attenuating ineffective ones (Collins et al., 2005; West & Aiken, 1997). This warrants a comprehensive and in-depth analysis into the relationship between characteristics of FoF interventions and intervention effectiveness. We conducted a review and meta-analysis of randomized controlled trials (RCTs) to determine which overarching characteristics of interventions are effective in reducing FoF in community-dwelling older people.

Methods

A systematic review and meta-analysis was performed. This study was registered at the PROSPERO international prospective register of systematic reviews, registration ID CRD42018080483.

The reporting of this review is in accordance with the PRISMA guidelines (Moher et al., 2009), see the supplementary data at the journal website. Other supplementary information is available in the appendices and on Open Science Framework (OSF), DOI: 10.17605/OSF.IO/2YU8H.

Search strategy

In 2007, Zijlstra et al. published a systematic review on RCTs assessing interventions to reduce FoF. This study was used as starting point for the current study. Based on the search by Zijlstra et al. (2007), an updated search was performed in the databases PubMed, EMBASE, PsycINFO, CINAHL and CENTRAL on July 19, 2019. Keywords relating to outcome (FoF), design (RCT) and population (older people) were combined with AND (search strategy available in Appendix A). Searches were restricted to publications written in English or Dutch and, given the updated search, to articles published after July 1st 2005. Articles from before July 2005 were obtained from the review by Zijlstra et al (2007). Additional search strategies included consulting international experts who recently published in the domain of FoF or falls, manually searching reference lists of previous reviews and meta-analyses, and searching for published articles when a potentially relevant protocol was found.

Outcome of interest

FoF was first conceptualized as “low perceived self-efficacy at avoiding falls” in 1990, when the Falls Efficacy Scale (FES) was developed by Tinetti, Richman and Powell (1990). Since then, FoF has been used to refer to cognitive constructs (e.g. balance confidence or fall-related self-efficacy) and affect-based constructs (e.g. concern or worry about falling) and they are used interchangeably. We used the term “fear of falling” as an umbrella term including all of these aspects.

Eligibility criteria

To select studies, the following inclusion criteria were used:

- The article reported on results of an RCT evaluating an intervention, including cluster-randomized controlled trials (at least three clusters per arm) and randomized crossover trials, with assessments at similar moments in time (e.g. after the intervention) for all intervention arms.
- The mean age of the total population was 65 years or over.
- Study participants were older people living at home (non-institutionalized).
- FoF was included as a primary or secondary outcome of the study and the article reported on results of this outcome.
- The control group received either care as usual or no intervention (including wait list controls). An educational booklet for the control group or other sham interventions were also seen as interventions.

The following exclusion criteria were used:

- The article was written in a language other than Dutch or English. Even though searches were restricted to English and Dutch articles, this was used as an exclusion criterion as well. Full-text articles are sometimes written in other languages than the abstract and search filters do not always recognize these other languages.
- The study was performed in a specific patient group characterized by a disease or medical condition (e.g. Parkinson's disease, stroke, hip fracture) or a population that had recently received treatment for a medical condition (e.g. hip arthroplasty).

No criteria regarding the type of intervention were formulated.

Study selection process

Title and abstract screening

To facilitate a systematic comparison of titles and abstracts against criteria, criteria were applied in the following order: design, age of the population, living situation of the population, health of the population, outcome and language. For practical reasons, the control group was not yet assessed in the title and abstract phase. When titles and abstracts met inclusion criteria or when doubt

remained after checking titles and abstracts, articles proceeded to the next phase: full-text screening.

The first 200 titles and abstracts were screened independently by two authors (MK and GARZ). There was 95.5 % agreement on whether full-text screening was required; kappa was 0.67 (95% CI: 0.462; 0.869), indicating good interrater reliability (Higgins & Green, 2011a). This agreement was considered sufficient for one author to screen the remaining titles and abstracts (MK). As this study concerns an update from the review by Zijlstra et al. (2007) and we added one extra criterion regarding the control group, articles from this review were screened against eligibility criteria as well.

Full-text screening

Full-texts were checked against criteria in the following order: language, design, control group, age of the population, living situation of the population, health of the population and outcome. Full-text articles were screened by one reviewer (MK). When an article lacked information on a criterion (e.g. the living situation of the population was not reported), the study was excluded. In cases of doubt with respect to inclusion, a second reviewer was consulted to achieve consensus (GIJMK, RC or GARZ).

Data extraction

A data-extraction form was developed and pilot tested among six of the authors (MK, KD, GIJMK, K-LC, DK, SI). Data from one study were extracted independently by teams of two authors. Completed data extraction forms were checked to see whether similar data had been extracted. In addition, suggestions by authors were used to improve the data-extraction form. Subsequently, data from each study were extracted independently by teams of two authors. Extracted data included bibliographical information and details on the design of the study, participant characteristics, FoF measures, intervention content and delivery, and results. The final extraction form can be viewed online. FoF results were extracted for all intervention arms, for the first available assessment after the intervention and at the last assessment available. For crossover RCTs, the data before the crossover was extracted. After the data extraction, intervention types were determined by two authors (MK and GARZ)

based on the focus indicated in the title, abstract, introduction and methods section of an article. Risk of bias was assessed in a separate extraction form with the Cochrane Collaboration's Tool for assessing risk of bias in randomized trials (Higgins et al., 2011), which covers selection bias (two items), performance bias, detection bias, attrition bias, reporting bias and other types of bias. Each of the seven items in the tool was scored with a low, high or unclear risk of bias. This form was pilot tested as well. Disagreements in extracted information were resolved in consensus meetings between authors MK and RC or GARZ.

Protocols and design articles were checked for additional intervention details when a reference to such a paper was included. When information from protocols was contradictory to effect articles, the effect article had priority. When results were not reported in a format that could be analyzed (e.g. in figures only or no measure of variance), authors were contacted for additional information. When data could not be provided, studies were excluded from the meta-analysis, but included in the systematic review section of this study.

Analysis

For each study, a standardized mean difference (SMD) was estimated by the method of Cohen, resulting in the sample estimate Cohen's *d*. Standardization of effects is appropriate when different scales are used (Higgins & Green, 2011b). To calculate Cohen's d, the number of participants, follow-up means and standard deviations for the intervention and control group were used. A complete overview of formulas is available online. SMDs were interpreted as follows: 0.2 a small effect, 0.5 a moderate effect and 0.8 a large effect (Cohen, 1988). A random effects meta-analysis model was used to summarize SMDs for the first available follow-up after the intervention. Whereas fixed effects meta-analysis attributes heterogeneity in effect estimates only to random sampling error, a random effects approach also allows for between-study heterogeneity.

First, main effects on FoF were estimated, without a focus on intervention characteristics. Second, associations between intervention characteristics and the effects of FoF interventions were determined by univariate meta-regression. Meta-regressions included categorical intervention characteristics which compared studies with an intervention characteristic (coded as 1) with all studies without that characteristic (coded as 0). The

regression coefficient obtained from a meta-regression analysis using this 0-1 coding scheme is the difference in predicted outcome variable (i.e. difference in the SMD) between interventions with and without the characteristic in question. Furthermore, we analyzed continuous intervention characteristics which investigated change in the SMD for a one unit change in the intervention characteristic. The type of intervention (e.g. exercise, education, cognitive behavioral) was also analyzed with meta-regression in the same way. The following categorical variables were investigated: intervention type, whether FoF was a primary outcome of the study, whether FoF was a topic of the intervention, setting (where intervention was delivered, i.e. at home, in the community or both), delivery method (e.g. face-to-face, written materials - such as manuals and exercise diaries - or telephone), tailoring (adaptation of the intervention to the individual based on a formal or informal assessment by the supervisor), group format (individual, group or both), presence of supervision, type of supervisor, whether the supervisor participated in intervision sessions and whether the supervisor had experience in working with older people. Intervision sessions were defined as meetings or phone calls during the intervention, either between a group of supervisors or between supervisors and an investigator or manager. The following continuous variables were investigated: contact time with a facilitator and duration of the intervention. The number of intervention sessions is presented in the results, but not analyzed with meta-regression. Whether the number of sessions is related to an outcome can be dependent on the intervention content. Therefore, the number of sessions was not considered suitable for analysis.

When a study had multiple intervention arms, only one intervention arm was included in meta-analysis in order to avoid correlated data in the meta-analysis. The arm used in the primary analysis was always the intervention arm mentioned first in the abstract. Heterogeneity (variability in intervention effects) was quantified with I^2 and tested by Q test statistics. The following interpretations for I^2 from the Cochrane handbook were used: “0% to 40%: might not be important; 30% to 60%: may represent moderate heterogeneity; 50% to 90%: may represent substantial heterogeneity; 75% to 100%: considerable heterogeneity” (Higgins & Green, 2011c) (Higgins and Green, 2011c). As we investigated overarching characteristics and included a wide

range of intervention types, we expected heterogeneity to be high. Part of the heterogeneity could possibly be explained by one or more of the characteristics. Publication bias was assessed by visual inspection of funnel plots and Egger's test. Outliers were determined by visual inspection of the forest plot and funnel plot.

Sensitivity analyses were performed to assess the influence of methodological decisions which were made. The following sensitivity analyses were performed:

a) performing meta-analysis and meta-regressions without outliers;

b) performing a meta-analysis on cognitive-based FoF measures (e.g., FES, Activities-specific Balance Confidence scale (ABC)) and affect-based FoF measures (e.g., Falls Efficacy Scale-International (FES-I), the Survey of Activities and Fear of Falling in the Elderly (SAFFE)) separately;

c) repeating meta-regressions with the other intervention arm of a study (in case more than one intervention arm was involved);

d) repeating meta-regressions without cluster RCTs;

e) repeating meta-regressions with the results of the latest assessment (to evaluate long-term effects instead of the effects at the first follow-up after the intervention);

f) performing a meta-regression of the association of study quality (the number of risk of bias items scored as high risk, as a continuous variable) with the SMD.

All analyses were performed with STATA version 15. The significance level was set at 0.05 for meta-regressions. Syntaxes and data can be viewed online.

Results

Search results

The process of article selection is shown in Figure 1. Searching literature databases resulted in 10,410 unique hits of which 385 full-text articles remained after title and abstract screening. Full-text screening resulted in 66 articles suitable for inclusion. Screening of reviews, expert consultation and protocols from intervention descriptions yielded 23 additional articles. In total, 89 articles providing data on 62 unique RCTs were included in qualitative synthesis. Forty-nine studies provided data that was suitable for inclusion in meta-analysis.

Description of studies

Studies were conducted in 18 different countries, often in Europe (n=21) or North America (n=12). Most studies were parallel-group RCTs (n=53), of which the majority had two study arms (n=39). The mean age of the population varied from 65 to 86 years. One study recruited only women. Five studies recruited participants with FoF, five with a fall risk, five with a history of falls, three without a history of falls, and two with FoF or a history of falls. Other criteria on which participants were selected related to physical activity - including prior participation in exercise and activity avoidance - or were related to health, such as physical functioning, frailty, mobility complaints, and perceived general health. Some studies did not report on basic information, such as the country in which the study was conducted (n=8), or the number of women included in the study (n=1). Three studies did not report on the mean age, but only reported a minimum age as part of their inclusion criteria. A table with an overview of the study characteristics is available online.

FoF was a primary outcome in eight studies. Other primary outcomes that were used often were falls or fall risk (n=13) and balance or balance performance (n=21). Seven studies used more than one outcome measure to measure FoF. The first available measurement was often directly after the intervention (n=53), other studies assessed FoF for the first time between 4 and 48 weeks after the intervention (n=8). One study only assessed FoF at the halfway point of the intervention. Nineteen studies measured FoF more than one time. The last available assessment for these studies ranged from 12 to 96 weeks after the end of the intervention. The majority of studies (n=61) used scales with multiple items and five studies used a one-item question to assess FoF.

The number of items on which studies scored a high risk of bias ranged from two to four out of seven. Item three and four of the Cochrane risk of bias tool, regarding blinding of participants and personnel (performance bias) and blinding of outcome assessment (detection bias), scored a high risk of bias in all studies. This was due to the nature of the interventions, as it was not possible to blind participants and personnel to group allocation in, for example, exercise interventions. Furthermore, self-reported FoF measures were used and as participants were not blinded, participants were aware of their allocation when

reporting their FoF. The risk of bias scoring per item for all studies can be viewed online.

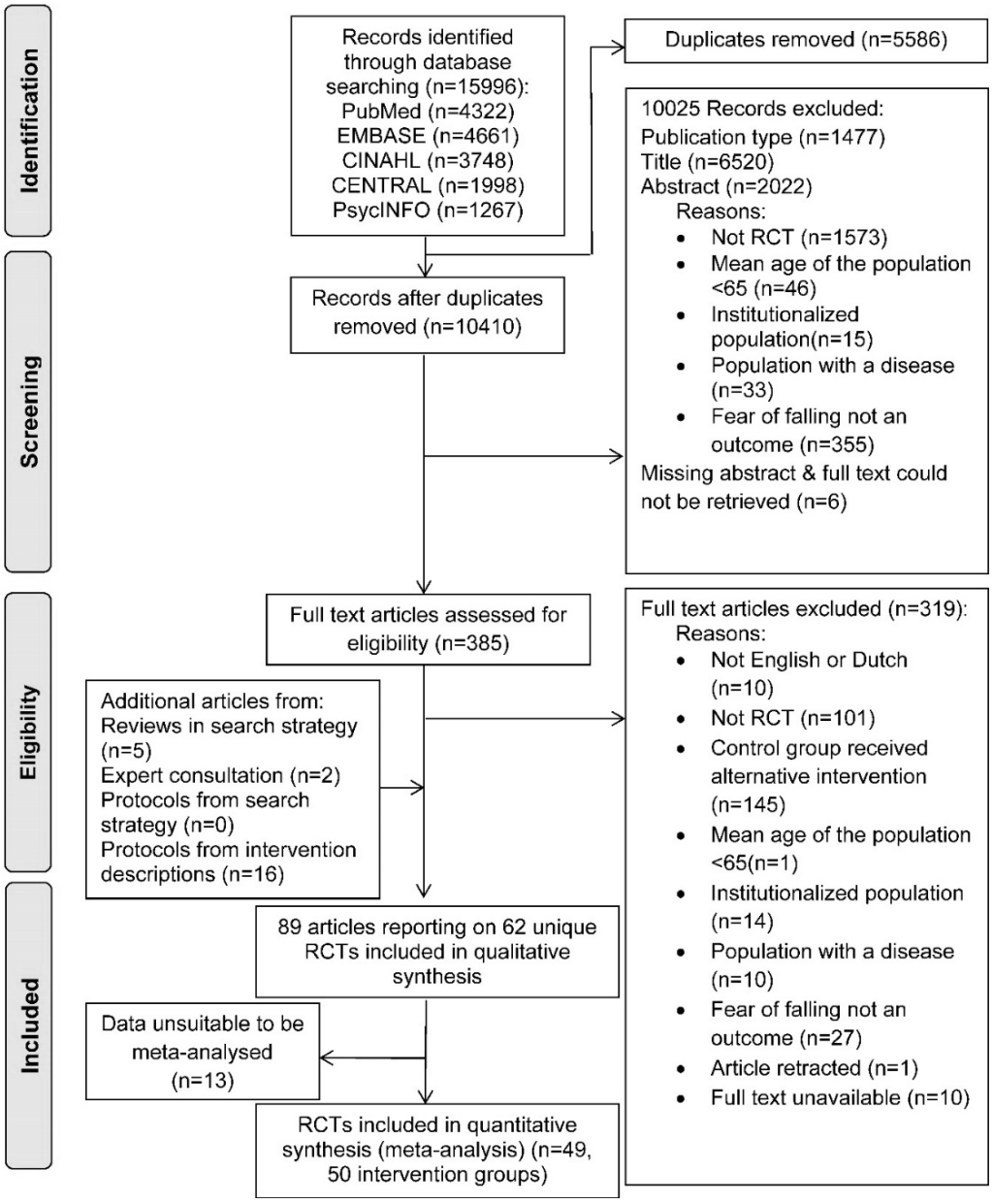

Figure 1. Flow-chart of study selection process. Adapted from Moher et al. (2009).

Description of interventions

Sixty-two studies described 79 interventions. In Appendix B, a description of intervention characteristics is given. For references of studies included in this review, see the online material. Most interventions were exercise interventions (n=61). Strength training and balance training were often combined (n=20), sometimes in combination with endurance training (n=9). Other types included assessment-based care (n=6), in which care is delivered based on a formal assessment, assessment-based home modification (n=4), cognitive behavioral programs (n=3), a referral protocol for emergency ambulance visits (n=1), nutritional supplementation (n=2) and mental imagery (n=1), in which a stable position is visualized. Five studies focused on education. Of the interventions included in meta-analysis, eight interventions specifically addressed fear of falling as a topic in the intervention (Dorresteijn et al., 2016; Faes et al., 2011; Freiberger et al., 2012; Markle-Reid et al., 2010; Parry et al., 2016; Siegrist et al., 2016; van Haastregt et al., 2000; Zijlstra et al., 2009).

Interventions were often delivered in a home setting (n=25), community setting (n=27) or in a combination of home and community settings (n=14). Ten interventions did not report on the setting and for three interventions the setting could vary per individual. Most interventions delivered at least one of their components face-to-face (n=62, excluding introductory sessions), yet components were also delivered via written materials (n=34), game technology (n=10) and telephone contact (n=12). About two thirds of the interventions were tailored (n=51) and about half delivered individually (n=36). Most interventions were supervised (n=71) and a range of different supervisors delivered the interventions. All had received training to deliver the intervention or had expertise in delivering the intervention from their professional background. The most common supervisors were physiotherapists (n=19), nurses (n=8), Tai Chi instructors (n=6) and occupational therapists (n=6). For 10 interventions, it was specifically reported that the supervisor had experience in working with older people. For 22 interventions, intervision for the supervisor, via meetings with peer supervisors or managers, was reported. The duration of interventions varied from one week to one year, the number of planned intervention sessions varied from 1 to 336 and the planned contact-time with the supervisor varied from 0.5 to 56 hours.

Some studies did not report where the intervention was performed (n=10), whether it was performed in a group or individually (n=7), whether supervision was available (n=2), the type of supervisor (n=10), number of planned sessions (n=9) or contact time with a facilitator (n=25). Study authors reported that the intervention was effective in reducing FoF for 40 interventions. No study reported a significant increase in FoF for the first available follow-up.

Outcomes of analyses

Meta-analysis

Fifty study arms were pooled in a meta-analysis (Figure 2). The number of participants included in the studies at the first available follow-up after the intervention ranged from 7 to 634 in the intervention groups and from 5 to 600 in the control groups. Pooling all interventions together resulted in an estimate of the SMD of -0.36 (95% CI: -0.48; -0.24), indicating a significant small to moderate reduction in FoF. There was considerable between-study variability (I^2: 79.4%. p<0.001). Visual inspection of the funnel plot and Egger's test for publication bias revealed significant publication bias (p<0.001). Six outliers could be identified from the funnel plot (Hafström et al., 2016; Hosseini et al., 2018; Mortazavi et al., 2018; Nguyen & Kruse, 2012; Nick et al., 2016; Pirauá et al., 2019). Meta-analysis without these six outliers resulted in a pooled SMD of -0.20 (95% CI: -0.28; -0.12) and heterogeneity was 53.6% (p<0.001). The overall estimates for affect based and cognitive based measures were -0.36 (95% CI: -0.50; -0.21. I^2: 78.0%) and -0.37 (95% CI: -0.57; -0.17. I^2: 80.9%), respectively. For the funnel plot and the forest plots of the sensitivity analyses, see the online material.

Meta-regression

The characteristics "FoF as a primary outcome" or "FoF as a topic of the intervention" were not significantly associated with the SMD in FoF for the first follow-up after the intervention (Table 1). Similarly, no significant associations with the SMD were found for most types of interventions. Only holistic exercise (i.e. Tai Chi, yoga, Ving Tsun or Pilates) yielded a significant association with the SMD of -0.823 (95% CI:-1.255; -0.392. p<0.001). This indicates holistic exercise

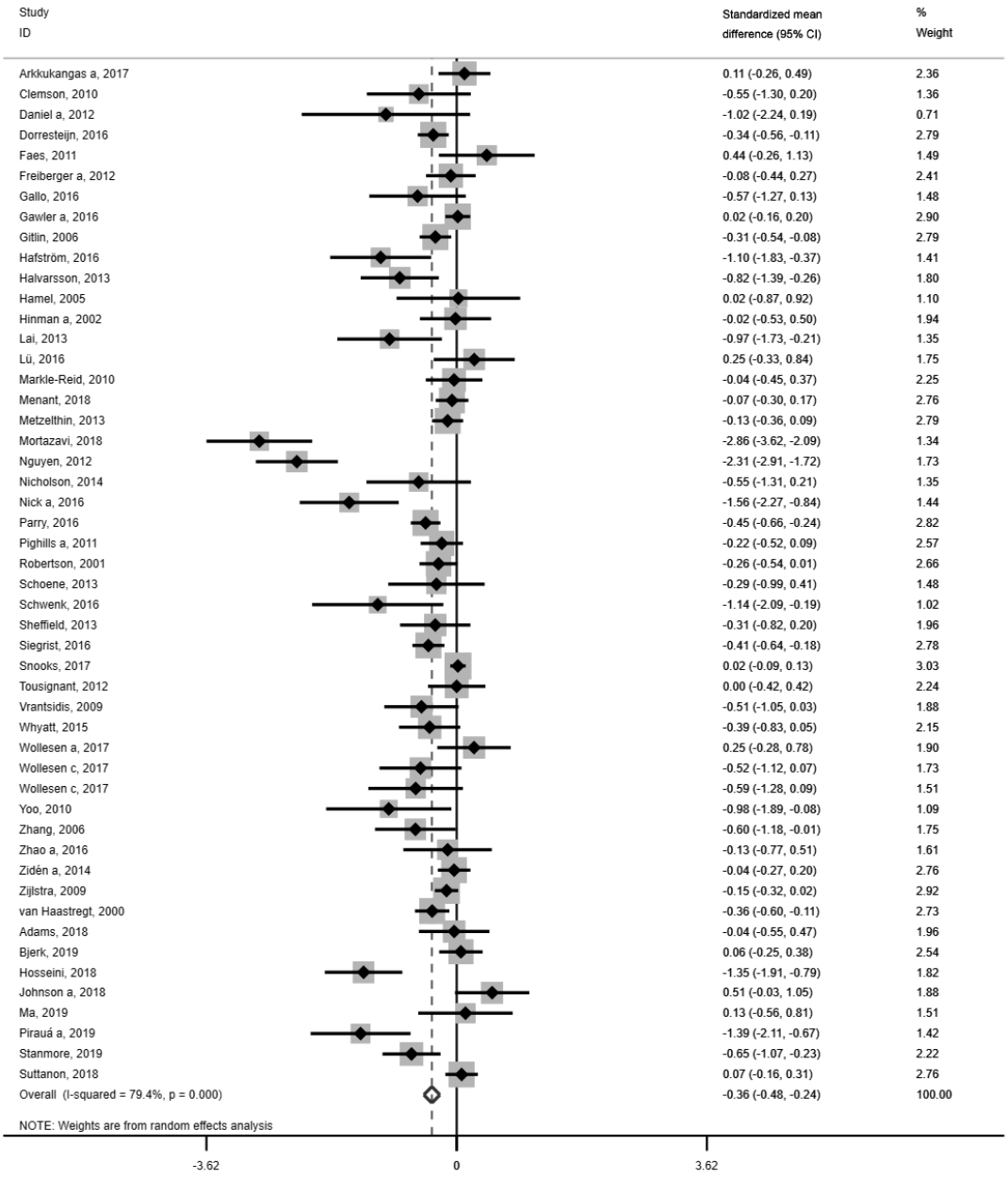

Figure 2. Forest plot of the 50 intervention arms included in the meta-analysis of the first available follow-up after the intervention. A negative standardized mean difference implies a decrease in fear of falling. A positive standardized mean difference implies an increase in fear of falling.

interventions were more effective in reducing FoF than all other interventions combined.

The setting of interventions was significantly associated with the SMD. Delivery in a community setting was significantly associated with a decrease in the SMD of -0.528 (95% CI: -0.894; -0.161. p=0.006), indicating that interventions delivered in the community were more effective in reducing FoF than those that are delivered at home or in a combination of home and community setting. Furthermore, delivery at home (B: 0.384. 95%CI: 0.002; 0.766. p=0.049) was significantly less effective in reducing FoF, as were written materials (B: 0.452. 95%CI: 0.088; 0.815. P=0.016). In addition, tailoring resulted in a statistically significant increase in the SMD of 0.687 (95% CI: 0.364; 1.011. p<0.001), meaning that interventions which were delivered in a tailored format were significantly less effective than those that were not. In general, whether supervision was present, whether the supervisor was experienced in working with older adults or participated in intervision yielded no significant associations, as did most supervisor types. However, supervision by a Tai Chi instructor was significantly associated with a decrease in the SMD of -1.047 (95 % CI: -1.598; -0.496. p<0.001), indicating that interventions which were supervised by a Tai Chi instructor were more effective in reducing FoF than those that did not include supervision by a Tai Chi instructor. Duration of the intervention yielded no significant association, but contact time with a facilitator approached significance (B: -0.017. 95 % CI: -0.036; 0.002. p=0.083), meaning each hour increase in contact time was associated with a decrease in the SMD in FoF of 0.017.

Similar results were obtained when performing meta-regressions without cluster RCTs and with the second (n=15) or third arm (n=2) of the intervention (see online supplementary material). In a meta-regression of study quality - as scored with the Cochrane risk of bias tool - and the SMD, no significant association was found. When performing meta-regressions without outliers, supervision by home care professionals and a combination of strength, balance and endurance training were significantly less effective in reducing FoF (B homecare supervision: 0.725, 95% CI: 0.051; 1.399. p=0.036. n=1 out of 33; B strength, balance, endurance: 0.227. 95% CI: 0.018; 0.437. p=0.034. n=6 out of 44). Holistic exercise, supervision by a Tai Chi instructor, written materials,

tailoring, or setting are no longer significantly associated. When performing meta-regressions with a smaller sample of studies which assessed FoF at a long-term follow-up (n=17), previously mentioned significant results of the main analysis disappear, yet ambulance referral to falls services is significantly less effective in reducing FoF (B: 0.273. 95% CI: 0.034; 0.511. p=0.028. n=1 out of 17).

Table 1. Meta-regression results for intervention characteristics and types of interventions for the first available follow-up after the intervention.

Characteristic	Studies (n)	Studies with characteristic (n)	B[a]	SE	95% CI	P-value	Residual heterogeneity (%)
Primary outcome is FoF	50	7	-0.160	0.241	-0.645; 0.325	0.511	79.12
FoF as topic	47	7	0.249	0.244	-0.243; 0.740	0.313	79.19
Type of intervention							
Exercise	50	37	-0.294	0.185	-0.666; 0.078	0.119	79.20
Strength training	50	16	0.202	0.184	-0.168; 0.572	0.277	79.52
Balance training	50	18	0.189	0.179	-0.170; 0.548	0.296	79.66
Endurance training	50	11	0.290	0.207	-0.126; 0.707	0.167	78.64
Strength, balance and endurance training	50	6	0.447	0.242	-0.041; 0.934	0.072	78.44
Strength and balance training	50	4	-0.105	0.322	-0.752; 0.542	0.746	79.45
Strength and endurance training	50	2	0.391	0.507	-0.628; 1.410	0.444	79.49
Holistic exercise (Tai Chi, yoga, Ving Tsun, Pilates)	50	8	-0.823	0.215	-1.255; -0.392	**<0.001***	74.28
ADL exercises[b]	50	1	0.843	0.658	-0.480; 2.166	0.206	79.50
Feldenkrais	50	1	-0.117	0.626	-1.376; 1.141	0.852	79.67
Dual tasking	50	4	0.058	0.334	-0.614; 0.730	0.863	79.76
Cognitive behavioral program	50	3	0.091	0.336	-0.585; 0.766	0.789	79.57

Education	50	2	0.642	0.427	-0.217; 1.500	0.139	79.11
Psychological education	50	1	0.843	0.658	-0.480; 2.166	0.206	79.50
Mental imagery	50	1	0.425	0.732	-1.047; 1.897	0.564	79.76
Assessment-based intervention	50	9	0.304	0.209	-0.116; 0.724	0.151	79.59
Assessment-based care	50	6	0.275	0.246	-0.220; 0.770	0.269	79.74
Assessment-based home modification	50	3	0.230	0.346	-0.466; 0.926	0.510	79.72
Referral	50	1	0.423	0.555	-0.693; 1.539	0.450	78.15
Setting							
Home	43	17	0.384	0.189	0.002; 0.766	**0.049***	77.27
Community	43	19	-0.528	0.181	-0.894; -0.161	**0.006***	77.96
Both home and community	43	7	0.252	0.262	-0.278; 0.782	0.342	79.53
Tailoring	49	31	0.687	0.161	0.364; 1.011	**<0.001***	72.73
Delivery method							
Face-to-face	45	42	0.411	0.422	-0.440; 1.261	0.335	79.54
Written materials	45	20	0.452	0.180	0.088; 0.815	**0.016***	77.34
Telephone	45	9	0.340	0.227	-0.117; 0.797	0.141	78.79
Game technology	45	5	-0.022	0.311	-0.649; 0.605	0.944	79.81
Audio cassette	45	3	0.259	0.401	-0.549; 1.066	0.522	80.04
Video	45	3	0.274	0.362	-0.457; 1.004	0.454	79.97
Nutritional supplement	45	0	-	-	-	-	-
Sensor-based technology	45	1	-0.721	0.770	-2.274; 0.831	0.354	79.73
Group format							
Individual	46	23	0.328	0.177	-0.029; 0.686	0.071	77.34
Group	46	18	-0.369	0.183	-0.738;-0.000	0.050	78.07
Combination of group and individual	46	5	0.040	0.297	-0.559; 0.640	0.892	78.54
Supervision							
Supervision present	48	47	0.701	0.682	-0.671; 2.074	0.309	78.54
Experience	41	7	0.418	0.264	-0.116; 0.951	0.121	80.82
Intervision	43	16	0.232	0.197	-0.166; 0.630	0.247	80.42
Supervisor type							
Physical therapist	38	14	0.249	0.219	-0.194; 0.693	0.262	81.49
Occupational therapist	38	5	0.275	0.303	-0.341; 0.900	0.371	81.61
Nurse	40	7	0.267	0.251	-0.240; 0.775	0.293	80.66
Healthcare assistant	38	1	-0.035	0.629	-1.310; 1.240	0.956	81.40
Homecare	38	1	0.951	0.661	-0.389; 2.291	0.159	80.99

Social worker	38	1	0.391	0.626	-0.880; 1.661	0.537	81.43
Case manager	38	1	0.388	0.652	-0.933; 1.710	0.555	81.65
Geriatric psychologist	38	1	0.869	0.706	-0.562; 2.301	0.226	81.39
Tai Chi instructor	38	5	-1.047	0.272	-1.598;-0.496	**0.000***	76.49
Yoga instructor	38	1	-1.169	0.702	-2.592; 0.254	0.104	80.47
Feldenkrais practitioner	38	1	-0.097	0.681	-1.478; 1.284	0.888	81.66
Fitness instructor	38	2	-0.339	0.573	-1.499; 0.826	0.561	81.58
Fall prevention instructor	38	1	0.341	0.644	-0.965; 1.647	0.600	81.66
Dietician	38	1	0.388	0.652	-0.933; 1.710	0.555	81.65
Peer mentor	38	1	0.446	0.620	-0.811; 1.702	0.477	80.83
Caregiver	38	1	0.869	0.706	-0.562; 2.301	0.226	81.39
Postural stability instructor	38	1	0.390	0.672	-0.973; 1.752	0.565	81.68
Researcher	38	3	-0.285	0.394	-1.085; 0.515	0.474	81.21
Research assistant	38	1	0.408	0.672	-0.955; 1.772	0.547	81.67
Physical education student	38	1	0.686	0.683	-0.699; 2.070	0.322	81.47
Ving Tsun coach	38	1	0.555	0.712	-0.888; 1.998	0.440	81.63
Contact hours with a facilitator	NA	NA	-0.017	0.009	-0.036; 0.002	0.083	81.35
Duration of intervention (weeks)	NA	NA	0.002	0.011	-0.019; 0.023	0.857	79.57

Note: CI: Confidence interval; NA: non-applicable.
a: The regression coefficient. For categorical variables, the regression coefficient represents the difference in the standardized mean difference (SMD) between interventions with and without the characteristic in question. For continuous variables, the regression coefficient is the change in the SMD for a one unit change in the intervention characteristic.
b: Activities of Daily Living
*p<0.05.

Discussion

Main findings

The present meta-analysis of 50 intervention arms showed that interventions in general, conducted in community-dwelling older people, are associated with a significant small to moderate reduction in FoF at the first available follow-up after the intervention (SMD: -0.36. 95% CI: -0.48;-0.24). Most intervention types (e.g. cognitive-behavioral, assessment-based, education etc.) and overarching characteristics (e.g. supervisor, delivery method, group format etc.) were not significantly associated with the Standardized Mean Difference in FoF at the first follow-up after the intervention. However, interventions with holistic exercise, supervision by a Tai Chi instructor and delivery of the intervention in a

community setting were more effective than interventions without these characteristics. Interventions delivered at home or with written materials and tailoring were significantly less effective in reducing FoF at the first follow-up after the intervention. Sensitivity analysis revealed that these significant results disappear when six outliers are removed, four of which were holistic exercise interventions without tailoring or written materials, delivered in a community setting.

All included studies scored a high risk of bias on two (out of seven) items: blinding of participants and personnel and blinding of outcome assessment. However, blinding of participants is usually impossible in these types of studies and when the measurement of FoF is based on self-report by unblinded participants, the risk of detection bias is high. As this occurred in all studies, it is unlikely to have had an impact on the findings of this specific analysis.

Previous research

The majority of interventions included in this study were exercise interventions. In a review which included 41 exercise studies, Büla et al. (2011) identified no clear superiority of one type of exercise over others. This was confirmed in a large meta-analysis of 24 exercise studies by Kendrick et al. (Kendrick et al., 2014), in which subgroup analyses indicated no significant difference in effect on FoF by different exercise types. These findings were not confirmed in the present study, in which holistic exercise (Tai Chi, yoga, Ving Tsun or Pilates) was significantly associated with the effect, indicating that holistic exercise interventions were more effective in reducing FoF than all other interventions combined. This discrepancy may be due to differences in inclusion criteria and the inclusion of more recent studies, such as the inclusion of the highly effective Tai Chi intervention by Mortazavi et al. (2018). Results correspond with those of a meta-analysis by Rand, Miller, Yiu and Eng (2011) including 24 studies, in which Tai Chi was associated with a significant moderate effect size of 0.47 (95%CI: 0.30; 0.63), while small significant effects were found for exercise and multifactorial interventions. In addition, effects did not vary with exercise frequency, duration of the intervention, group format, primary aim, and method of outcome measurement in the previously mentioned meta-analysis by Kendrick et al. (2014). This is partly confirmed by the results of the current study

in which duration of the intervention and primary outcome were not significantly associated with the SMD and similar meta-analytical effects were found for cognitive- and affect-based outcome measures.

Other characteristics which have been investigated previously are setting, delivery method and group format. In a meta-analysis of FoF treatment programs by Jung et al. (2009), including six studies, community (n=2)- and home-based interventions (n=1) were significantly effective in reducing FoF and facility-based interventions (n=3) were not. In the current study, interventions delivered in a community setting were significantly more effective than those not solely delivered in the community. No distinction was made between interventions delivered in the community or a facility, such as an outpatient department, in the current study. A few previous reviews investigated the use of virtual reality games. In a review of nine virtual reality studies, Neri et al. (2017) found that virtual reality games were superior compared to conventional interventions for reducing FoF. In contrast, in the current study, a meta-regression of delivery through video games yielded no significant association. This is in line with a systematic review and meta-analysis of three studies by Dennett et al. (2015) in which computer-based interventions did not differ from physiotherapy in improving falls efficacy or balance confidence in adults. In a meta-analysis of six CBT interventions, individual-based interventions achieved bigger effects than group-based interventions (Liu et al., 2018). In the present study, one of our sensitivity analyses indicated a benefit of group interventions above those delivered individually or in a combination of group and individual. However, the analysis on group format was not limited to CBT interventions in the present study. Finally, a tailored format and delivery with written materials were less effective in reducing FoF when compared to interventions without these characteristics. Tailoring based on an assessment may result in increased awareness of personal risk factors for falls or a confrontation with a poor physical condition, and this may lead to an increase in the perception of vulnerability. Similarly, this may be the case if participants self-monitor themselves by the use of written materials such as an exercise diary. When appropriate tools or skills are not offered to help individuals to cope with this, tailoring may be counterproductive in reducing the FoF. Importantly, the type of tailoring was not considered in this review and may have an influence

(Schepens et al., 2011). In addition, what exactly was delivered through written materials, i.e. self-monitoring or exercise instruction, could matter for intervention effectiveness.

Strengths and limitations

We were able to include 62 unique RCTs. This review is one of the largest overviews of RCTs with FoF as outcome in community-dwelling older people to date. Data extraction was done with a pilot tested form, ensuring systematic extraction. However, systematic reviews are reliant on published research, which makes them susceptible to publication bias. By searching a wide range of databases and consulting experts worldwide, attempts were made to limit publication bias, but there was evidence of publication bias from the funnel plot and Egger's test. If studies which show increases in FoF were not included in this meta-analysis, effect sizes may be overestimated. Furthermore, reporting on whether facilitators followed the intervention protocol in practice and whether participants adhered to the intervention program was limited, therefore these elements were not considered in the current review.

Meta-regressions were conducted with only one independent variable per analysis. Because of small numbers of studies in some of the categories, more extended analysis with several independent variables were not suitable. Furthermore, the small number of studies in some of the categories may have led to insufficient power to detect associations between some of the characteristics and the intervention effects. In addition, due to the exploratory nature of this study, no multiple-testing correction was performed and the significance level was set at 0.05. However, many meta-regressions were performed and this may lead to an increased risk of a type 1 error.

Moreover, only community-dwelling older people without specific diseases were included. The results of this review may not be generalizable to other populations, such as those with hip fracture or Parkinson's disease.

Implications and future research

The RCTs included in this review were mostly exercise interventions. Additional benefits of holistic exercise interventions versus all other interventions combined were found with meta-regression. Guidelines for falls prevention in, for example, the Netherlands heavily rely on exercise interventions to reduce

fall risk (Federatie Medisch Specialisten, n.d.) and Tai Chi is not yet recommended for those older people with FoF, who may benefit more from Tai Chi than other types of interventions. Furthermore, intervention effectiveness could also be determined by the people to whom the intervention is delivered. Characteristics of intervention participants may determine whether parameters or conditions for effectiveness of behavioral change methods are fulfilled (Peters et al., 2015). Evidence also indicates that people with poor vision or depressive symptoms are more likely to be severely afraid of falling (Kempen et al., 2009; van Haastregt et al., 2008). Such persons may require different intervention strategies and the impact of characteristics of participants on intervention effects is understudied. Future research may focus more on the impact of such characteristics, for example with individual patient data meta-analysis, which would have greater power to detect differences in effect between different patient characteristics. In addition, a limited set of characteristics relating to the supervisor was investigated in the current study. All supervisors were trained to deliver the intervention or had expertise from their professional background, but reporting on years of experience and training was generally lacking and not considered in this review. An analysis on supervisor type was performed, but as some types of supervisors only deliver some types of interventions (e.g. the Tai Chi supervisor that only delivers Tai Chi interventions), a categorization based on profession was not always distinctive. Future studies may focus more specifically on supervisor characteristics and intervention effectiveness, for example by taking into account levels of education and experience, and soft skills, such as communication and empathy. Furthermore, interactions between characteristics and content were not investigated in this review, but may represent an area for future research.

Moreover, the content of interventions is often divided into broad categories. For example, several reviews and meta-analyses investigated the effectiveness of multifactorial or multicomponent interventions (Büla et al., 2011; Whipple et al., 2017). This type of categorization gives rise to several problems. First of all, the term ‘multifactorial’ is used inconsistently, e.g. to indicate combinations of exercise and other components or multicomponent interventions in general. Secondly, this type of categorization may result in interventions appearing similar to each other, while in reality there is much

variety in intervention components. Although the content of interventions in the current study was categorized in more detail than in several previous reviews, the categorization was still rather broad. A more detailed examination of intervention components is warranted. This would require well-designed RCTs with very detailed reporting on intervention content. Steps in this direction have been made with the TIDieR template for intervention descriptions (Hoffmann et al., 2014), but reporting still leaves much to be desired. Finally, we ideally implement interventions that have an effect on a range of outcomes and individual studies have already shown that next to FoF, multiple outcomes can be affected (e.g. (Tomita et al., 2016; Zijlstra et al., 2009)). Future meta-analyses may want to evaluate whether, for example, falls risk decreases in those studies in which FoF decreases.

In conclusion, interventions with holistic exercise, supervision by a Tai Chi instructor or delivery of the intervention in a community setting were significantly more effective than interventions without these characteristics at the first follow-up after the intervention. Interventions delivered at home or with written materials and tailoring were significantly less effective than interventions without these characteristics. These are potential characteristics to take into account when designing and improving interventions for FoF in community-dwelling older people. Researchers have to weigh to what extent they would like to incorporate these characteristics into their interventions, also considering feasibility and cost-effectiveness.

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Conflict of Interest

None reported.

Data availability statement

The data that support the findings of this study are openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/2YU8H.

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Appendix A – Search strategy

Note: This appendix contains the search strategy for PubMed. For the search strategy in EMBASE, PsycINFO, CINAHL and CENTRAL, please see the online Open Science Framework project.

PubMed	
Search number	Query
#1	(((fear OR fearing OR fearful OR Fear[mh] OR anxiety OR anxious OR frightened OR concern OR concerns OR concerned OR afraid OR worry OR worries OR worrying OR worried OR confidence OR confident OR (self AND efficacy) OR self-efficacy) AND (fall OR falls OR falling OR fall-related OR balance OR Accidental Falls [mh])) OR balance-confidence OR (("FOF" AND (scale OR likert OR item OR items)) OR ((psychological OR psychosocial) AND (fall OR falls OR falling OR fall-related)) OR "falls efficacy scale" OR "falls efficacy scale international" OR "FES-I" OR "FES-NL" OR "FES-UK" OR (("FES" OR "rFES" OR "moFES" OR "mFES" OR "aFES" OR "amFES") AND (fall OR falls OR falling OR fall-related)) OR "fear of falling questionnaire" OR (("FFQ-R" OR "FFQ") AND (fall OR falls OR falling OR fall-related)) OR "activities specific balance confidence scale" OR "ABC-NL" OR "ABC-UK" OR ("ABC" AND (fall OR falls OR falling OR fall-related)) OR "mobility efficacy scale" OR ("MES" AND (fall OR falls OR falling OR fall-related OR mobility)) OR "survey of activities and fear of falling in the elderly" OR "SAFFE" OR ("SAFE" AND (fall OR falls OR falling OR fall-related)) OR "mSAFFE" OR "university of Illinois at Chicago fear of falling measure" OR "UICFFM" OR "UIC-FFM" OR "UIC FFM" OR "confidence in maintaining balance scale" OR "CONFbal" OR "geriatric fear of falling measurement" OR "GFFM" OR "concern about falling scale" OR ("CaF" AND (fall OR falls OR falling OR fall-related)) OR "falls handicap inventory" OR ("FHI" AND (fall OR falls OR falling OR fall-related)) OR "consequences of falling scale" OR ("CoF" AND (fall OR falls OR falling OR fall-related)) OR "concern about consequences of falling scale" OR "CONSfall"))

#2 Cochrane filter for RCTs (Cochrane Reviews, n.d.)*	((randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR randomised[tiab] OR placebo[tiab] OR drug therapy[sh] OR randomly[tiab] OR trial[tiab] OR groups[tiab] NOT (animals [mh] NOT humans [mh])) OR "Randomized Controlled Trials as Topic"[mh])
#3	((Aged[mh] OR ((aged OR age) AND 65) OR ((old OR older) AND (65 OR adult OR adults OR person OR persons OR men OR women OR people)) OR geriatric OR geriatrics OR senior OR seniors OR elderly))
#4	(#1 AND #2 AND #3)
#5	(#4) AND ("2005/07/01"[Date - Entrez] : "3000"[Date - Entrez])
#6	(#4) AND ("2005/07/01"[Date - Entrez] : "3000"[Date - Entrez]) Filters: English; Dutch

*Cochrane Reviews. (n.d.). *The Cochrane highly sensitive search strategies for identifying randomized trials in PubMed*. Retrieved 13-05-2019 from https://work.cochrane.org/pubmed

Appendix B – Intervention Characteristics

Table 1. Intervention characteristics of included studies.

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Adams, 2018[1]	exercise - s b e	both	face-to-face; written materials; dvd or audio format	yes	C	yes	PSI	no	yes	12	84[n]	12	=
Arkkukangas a, 2017[1]	exercise - s b e	home	face-to-face; written materials	yes	I	yes	PT	yes	yes	12	36[o]	5	=
Arkkukangas b, 2017	exercise - s b e	home	face-to-face; written materials	yes	I	yes	PT	yes	yes	12	36[o]	5	=
Bjerk, 2019[1]	exercise - s b e	home	face-to-face; written materials; telephone	yes	I	yes	PT	no	yes	12	72[p]	NR	NR
Chang, 2011	exercise - s b	both	written materials; telephone	no	C	yes	R	no	no	4	42	2.7	+[q]
Clemson, 2010[1]	exercise - s b	home	face-to-face; written materials; telephone	yes	I	yes	PT	no	yes	12	NR	NR	MFES: + ABC: =

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Daniel a, 2012[1]	exercise - s e	com.	face-to-face	no	G	yes	FI	no	no	15	NR	NR	+
Daniel b, 2012	exercise - s e	com.	face-to-face; game technology	no	G	yes	U	no	no	15	NR	NR	+
Dorresteijn, 2016[1]	cognitive behavioral	home	face-to-face; written materials; telephone; dvd	yes	I	yes	N	no	yes	16	NR	5.6	+
Duque, 2013	exercise - b	NR	face-to-face; game technology	yes	I	yes	PT	no	no	6	12	6	+
Faes, 2011[1]	exercise - ADL, education, psychological education	both	face-to-face; written materials	yes	G	yes	GPSY, PT and CG	yes	no	5	10	20	=
Freiberger a, 2012[1]	exercise - s b	both	face-to-face; written materials	yes	G	yes	FPI	no	yes	16	32	32	ABC: = PCOF[r]: =
Freiberger b, 2012	exercise - s b e	both	face-to-face; written materials	yes	G	yes	FPI	no	yes	16	32	32	ABC: = PCOF[r]: =
Freiberger c, 2012	exercise - s b, education, psychological education	both	face-to-face; written materials	yes	G	yes	FPI	no	yes	16	32	32	ABC: = PCOF[r]: =

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Gallo, 2016[1]	exercise - s b d	home	face-to-face; written materials	yes	I	yes	PT	no	no	26	130	NR	+
Gawler a, 2016[1]	exercise - s b e	home	face-to-face, written materials; telephone	yes	I	yes	PM	no	yes	24	72[o]	1.95[s]	NR
Gawler b, 2016	exercise - s b e	both	face-to-face, written materials,	yes	C	yes	PSI	no	yes	24	72[o]	24	NR
Gitlin, 2006[1]	assessment-based care	home	face-to-face; telephone	yes	I	yes	OT and PT	yes	yes	24	6	7.8	+
Hafström, 2016[1]	exercise - s b	home	written materials	no	I	no	-	-	-	6	42	NR	+
Halvarsson, 2013[1]	exercise - b	NR	face-to-face	yes	G	yes	PT	no	no	12	36	27	FES-I:+ 1-item: +
Hamel, 2005[1]	mental imagery	both	face-to-face; audio cassette	no	C	yes	NR	NR	NR	6	42	NR	=
Henwood a, 2008	exercise - s	NR	face-to-face	yes	NR	yes	EI	no	no	24	48	48	=
Henwood b, 2008	exercise - s	NR	face-to-face	yes	NR	yes	EI	no	no	24	48	48	=

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Hinman a, 2002[1]	exercise - b	com.	face-to-face; game technology	no	I	yes	RA	no	no	4	12	4	=
Hinman b, 2002	exercise - b	home	written materials	no	I	no	-	-	-	4	12	NR	=
Hosseini, 2018[1]	exercise - h	com.	face-to-face	no	G	yes	TI	no	yes	8	16	14.7	+
Johnson a, 2018[1]	exercise - s e	home	face-to-face; written materials	yes	I	yes	HC	yes	no	24	NR	NR	=
Johnson b, 2018	exercise - s e, nutrition	home	face-to-face; written materials; nutritional supplementation	yes	I	yes	HC	yes	no	24	NR	NR	=
Johnson c, 2018	nutrition	home	nutritional supplement	no	I	yes	NR	NR	NR	24	336	NR	=
Lacroix a, 2015	exercise - s b	both	face-to-face, written materials	yes	NR	yes	U	no	no	12	36	18	=
Lacroix b, 2015	exercise - s b	home	written materials; telephone	yes	I	yes	NR	NR	NR	12	36	NR	=
Lai, 2013[1]	exercise - e	com.	face-to-face; game technology	no	I	yes	U	no	no	6	18	9	+

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Lee, 2007	personal emergency response system	home	personal emergency response system	yes	I	no	-	-	-	8	NA	NR	=
Levy, 2016	exercise - e, virtual reality exposure	com.	face-to-face; virtual reality environment; game technology	yes	I	yes	NR	NR	NR	12	12	8	+
Lü, 2016[1]	exercise - s	com.	face-to-face	yes	G	yes	PES	no	no	12	36	36	=
Ma, 2019[1]	exercise - h	com.	face-to-face	no	G	yes	VTC	no	no	12	24	24	=
Markle-Reid, 2010[1]	assessment-based care	home	face-to-face; telephone	yes	I	yes	CM, N, OT, PT, and DI	no	yes	24	22.5[s]	NR	=
Menant 2018[1]	assessment-based care	var.	var.	yes	I	yes	var.	var.	no	var.	var.	var.	=
Metzelthin, 2013[1]	assessment-based care	home	var.	yes	I	yes	N and var.	var.	no	var.	var.	var.	=

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Mortazavi, 2018[1]	exercise - h	com.	face-to-face	no	G	yes	TI	no	no	10	30	30	+
Nguyen, 2012[1]	exercise - h	com.	face-to-face	no	G	yes	TI	no	no	24	48	48	+
Nicholson, 2014[1]	exercise - h	com.	face-to-face	no	G	yes	FI	no	no	12	24	NR	=
Nick a, 2016[1]	exercise - h	com.	face-to-face;	no	G	yes	YI	no	no	8	16	16	+
Nick b, 2016	education	NR	face-to-face; written materials	no	G	yes	NR	NR	NR	8	8	8	+
Parry, 2016[1]	cognitive behavioural	both	face-to-face; written materials	yes	I	yes	HA	no	yes	8	8	8	FES-I: + 1-item: +
Pighills a, 2011[1]	assessment-based home modification	home	face-to-face	yes	I	yes	OT	no	no	1[t]	1	1.75[s]	=
Pighills b, 2011	assessment-based home modification	home	face-to-face	yes	I	yes	HC	no	no	1[t]	1	1.75[s]	=
Pirauá a, 2019[1]	exercise - s	NR	face-to-face	no	NR	yes	R	no	no	24	72	NR	=
Pirauá b, 2019	exercise - s b	NR	face-to-face	no	NR	yes	R	no	no	24	72	NR	+

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Rendon, 2012	exercise - b	com.	face-to-face; game technology	yes	I	yes	PT	no	no	6	18	12[s]	+
Richeson, 2006	exercise - e	com.	face-to-face; written materials; pedometer; telephone	yes	C	yes	T	no	yes	12	NR	NR	=
Robertson, 2001[1]	exercise - s b e	home	face-to-face, written materials; telephone	yes	I	yes	N	no	yes	52	260	NR	+
Roller, 2018	exercise - h	com.	face-to-face	yes	G	yes	PI	no	no	10	10	7.5	+
Schoene, 2013[1]	exercise - e	home	written materials; game technology; telephone contact	yes	I	yes	NR	NR	NR	8	20[s]	NR	=
Schwenk, 2016[1]	exercise - b	com.	sensor-based technology	no	I	yes	U	no	no	4	8	6	+
Sheffield, 2013[1]	assessment-based home modification	home	face-to-face	yes	I	yes	OT	no	no	12	4[s]	9[s]	+

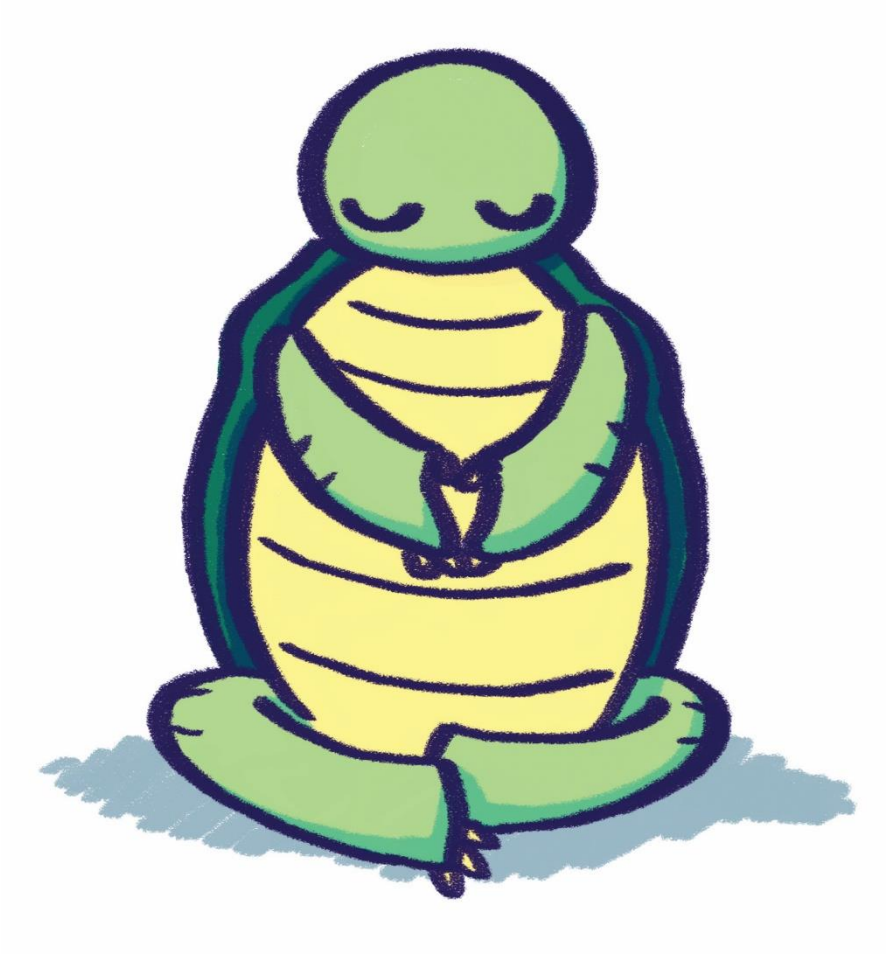
Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Siegrist, 2016[1]	exercise - s b	both	face-to-face; written materials	yes	C	yes	PT or R	no	yes	16	28	16	+
Snooks, 2017[1]	referral Emergency Ambulance Paramedics	var.	var.	yes	var.	var.	var.	var.	var.	var.	var.	var.	=
Stanmore, 2019[1]	exercise - s b flexibility	com.	face-to-face; game technology	yes	C	yes	PT	no	yes	12	36	NR	+
Suttanon, 2018[1]	exercise - s b e, education, assessment based home modification, assessment based care	home	face-to-face; written materials; telephone	yes	I	yes	PT	no	no	16	64	NR	=
Szturm, 2011	exercise - b	com.	game technology	yes	I	yes	PT	no	no	8	16	12	+
Thiamwong, 2014	exercise - b	home	written materials, DVD	yes	I	no	-	-	-	12	84	0.5	+
Tousignant, 2012[1]	exercise - h	com.	face-to-face	yes	G	yes	TI	no	no	15	30	30	=

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
van Haastregt, 2000[1]	assessment-based care	var.	var.	yes	var.	yes	N and var.	var.	var.	var.	var.	var.	+
Vrantsidis, 2009[1]	exercise - feldenkrais	com.	face-to-face; written materials; audio CD	no	G	yes	FP	no	no	8	16	13.3[s]	+
Wallsten, 2006	exercise - h	com.	face-to-face	no	G	yes	TI	yes	no	20	40	40	=
Whyatt, 2015[1]	exercise - b	NR	face-to-face; game technology	yes	I	yes	R	no	no	5	10	5	+
Wollesen a, 2017[1]	exercise - b d	com.	face-to-face	no	G	yes	U	no	no	12	12	12	+
Wollesen b, 2017	exercise - s	com.	face-to-face	yes	G	yes	NR	NR	NR	12	12	12	+
Wollesen SG1, 2017[1]	exercise - d	com.	face-to-face	no	G	yes	PT	yes	no	12	12	12	+
Wollesen SG2, 2017[1]	exercise - d	com.	face-to-face	no	G	yes	PT	yes	no	12	12	12	=
Yamada, 2012	exercise - e	both	written materials; pedometer	no	I	no	-	-	-	24	NR	-	+
Yoo, 2010[1]	exercise - e	com.	face-to-face	yes	G	yes	NR	NR	NR	12	36	36	FoF: + FES: =

Author, year[a]	Type of intervention[b]	Setting[c]	Format of delivery[d]	Tailoring[e]	Group format[f]	Supervision[g]	Supervisor type[h]	Experienced[i]	Intervision[j]	Duration intervention period (weeks)	Number of sessions[k]	Contact time(hours)[l]	Effective according to authors[m]
Zhang, 2006[1]	exercise - h	both	face-to-face; written materials	no	C	yes	TI	no	no	8	56	56	+
Zhao a, 2016[1]	exercise - b	NR	NR	NR	NR	NR	NR	NR	NR	16	48	NR	=
Zhao b, 2016	exercise - h	NR	NR	no	NR	NR	NR	NR	NR	16	48	NR	NR
Zidén a, 2014[1]	assessment-based home modification, assessment-based care	home	face-to-face, written materials	yes	I	yes	OT, PT, N or SW	no	yes	1[t]	1	NR	1 item: = FES-I: +
Zidén b, 2014	education	both	face-to-face, written materials	yes	G	yes	OT, PT, N or SW	no	yes	4	4[p]	8	1 item: = FES-I: +
Zijlstra, 2009[1]	cognitive behavioral	com.	face-to-face; written materials; video	yes	G	yes	N	yes	yes	8	NR	16	1-item: + MFES: + PCOF[r]: +

Abbreviations: ABC = Activities-Specific Balance Confidence scale. b = balance. C = combination. CG = caregiver. Com. = Community. CM = case manager. DI = dietician. d = dual. e = endurance. EI = exercise instructor. FI = fitness instructor. FP = fall prevention instructor. FES-I = Falls efficacy scale International. FES = Falls efficacy scale. FP = Feldenkrais practitioner. G = group. GPSY = geriatric psychologist. h = holistic (Tai Chi, yoga, Ving Tsun, Pilates). HA = healthcare assistant. HC = home care. I = individual. MFES= Modified falls efficacy scale. NA=non-applicable. N = nurse. NR = not reported, unclear or contradictory information. OT = occupational therapist. PES = physical education students. PCOF = perceived consequences of falling scale. PI = Pilates instructor. PM = peer mentor. PSI = postural

stability instructor. PT = physical/physiotherapist. R = researcher. RA = research assistant. s = strength. SW = social worker. T = team with backgrounds in therapeutic recreation, nursing, and health fitness. TI = Tai Chi instructor. U = unspecified trainer. Var. = Highly variable for each individual. VTC: Ving Tsun coach. YI = yoga instructor.[a 1] Indicates study and arm is used in the primary analyses. References belonging to the studies are available online. [b] Broad categorization of interventions into types. Based on focus indicated by authors in the title, abstract, introduction and methods section. [c] Introductory or explanatory sessions only make up a small portion of the intervention and were not included in determining the setting. For an intervention to be categorized as home, it had to be delivered in the house or apartment of the participant. In addition, walking in the house or neighbourhood with a route according to the participants choosing is also categorized as a home intervention. Community interventions are those interventions for which a participant has to go (or be transported) to an external location in the community. In certain cases, group interventions were assumed to be delivered in the community. [d] Delivery methods of the (components of) the intervention, excluding exercise equipment, home modifications or assistive devices. Face-to-face introductory sessions that make up a small part of the intervention are not included in the delivery methods. Checklists and exercise diaries are included in written materials. [e] yes: Description mentions a formal or informal assessment by a facilitator and adaptation of the intervention based on this assessment. This can be an adaptation in intensity, difficulty, speed, components, content of discussions and setting of goals. Does not include progression in difficulty based on the judgement of the participant itself. Has to be done by facilitator. no: Description does not mention an assessment as outlined before. The intervention may still progress in intensity, but this is not tailored to the individual. [f] Introductory or explanatory sessions only make up a small portion of the intervention and these were not included in determining the group format. [g] Yes: There is someone who interacts with and keeps track of the participant (can also be by telephone) during the intervention. This does not necessarily mean the supervisor is present at all sessions. No: Intervention is completely self-managed. [h] If someone only gives initial instructions, they do not qualify as supervisors and are not included here. [i] yes: Description mentioned supervisor with experience in working with older people. Had to be specifically reported. no: Experience described does not mention experience in working with older people or nothing specific is mentioned about the background of the supervisor, except for their profession. [j] yes: Description mentioned meetings or phone calls during the intervention between a group of supervisors or between supervisors and an investigator or manager. This meeting can serve one of several purposes: to learn from other supervisors, to motivate supervisors, to discuss unforeseen problems, to discuss difficult cases or ensure the proper implementation of the protocol. no: Description does not mention meetings or phone calls as outlined before. [k] Number of planned intervention sessions, with or without supervisor present (so including homework). Booster sessions were not counted as part of planned intervention sessions when they occurred after the first measurement moment. However, these are taken into account in analyses for the second measurement moment when applicable. Adherence is usually not considered, in some cases medians or an average is reported, if no information on planned moments was available. [l] Contact time with supervisor and other facilitators during the intervention period. Either face-to-face or by telephone. Adherence is usually not considered, in some cases medians or an average is reported, if no information on planned contact time was available. [m] Effectiveness is based on the interpretation of results reported by the authors for the first available follow-up after the intervention. +: improvement in FoF, =: no change in FoF. When multiple outcome measures were used, effectiveness is reported for each outcome measure separately. [n] If possible, daily at home. [o] Not including walks which were recommended. [p] Optional additional visits. [q] On 6 out of 16 ABC items. [r] Loss of functional independence & damage to identity subscales. [s] A value other than the planned number of sessions or contact time is given, such as a mean, median or midpoint of a range. [t] One session equals one week.



Chapter 3: Disentangling interventions to reduce fear of falling in community-dwelling older people: A systematic review and meta-analysis of intervention components

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Abstract

Purpose: Fear of falling (FoF) is a common and debilitating problem for older people. Most multicomponent interventions show only moderate effects. Exploring the effective components may help in the optimization of treatments for FoF.

Materials and methods: In a systematic review of five scientific literature databases, we identified randomized controlled trials with older community-dwelling people that included FoF as an outcome. There was no restriction on types of interventions. Two reviewers extracted information about outcomes and content of interventions. Intervention content was coded with a coding scheme of 68 intervention components. We compared all studies with a component to those without using univariate meta-regressions.

Results: Sixty-six studies, reporting on 85 interventions, were included in the systematic review. In the meta-regressions (n=49), few components were associated with intervention effects at the first available follow-up after the intervention, but interventions with meditation, holistic exercises (such as Tai Chi or Pilates) or body awareness were significantly more effective than interventions without these components. Interventions with self-monitoring, balance exercises, or tailoring were less effective compared to those without these components.

Conclusions: The identified components may be important for the design and optimization of treatments to reduce FoF.

Keywords: meta-analysis, systematic review, fear of falling, falls efficacy, aged, accidental falls, intervention component

Introduction

The percentage of people aged 60 or over is projected to increase worldwide from 12% in 2015 to 22% in 2050 (Steverson, 2018). One of the factors which is important in old age is fear of falling (FoF). The prevalence of FoF typically ranges between 21% and 85%, varying by the older population under study and the measure that is used (Lavedán et al., 2018; Malini et al., 2016; Scheffer et al., 2008; Tomita et al., 2018) . In 1990, FoF was conceptualized as "low perceived self-efficacy at avoiding falls", when the Falls Efficacy Scale (FES) was developed to operationalize this construct (Tinetti et al., 1990). In previous studies the term FoF has been used interchangeably to refer to cognitive-based constructs (e.g. balance confidence or fall-related self-efficacy) and affect-based constructs (e.g. concern or worry about falling). In this review, "fear of falling" is used as an umbrella term and includes both constructs. Both people with and without any recent falls experience FoF (Halfens et al., 2016; Makino et al., 2017; Zijlstra et al., 2007a) and it is associated with activity avoidance, social isolation, decreased physical functioning and future falls (Malini et al., 2016; Meulen et al., 2014; Scheffer et al., 2008). In addition, FoF is a debilitating condition that affects quality of life and may lead to premature nursing home admission (Cumming et al., 2000; Scheffer et al., 2008). Consequently, interventions to effectively reduce FoF in older community-dwelling people are important.

The effects of interventions on FoF have been summarized in previous studies. Meta-analyses of the effectiveness of interventions to reduce FoF mostly focused on specific types of interventions, such as cognitive behavioral therapy (CBT) or exercise, which have shown small to moderate reductions in FoF (Chua et al., 2019; Kendrick et al., 2014; Liu et al., 2018; Papadimitriou & Perry, 2019). In addition to meta-analyses that focus on the effectiveness of single types of interventions, there are also meta-analyses that have compared the effectiveness of different types of interventions. In such an analysis of 24 studies by Rand and colleagues (2011), Tai Chi was associated with a moderate effect and other exercise and multifactorial interventions with a small effect (Rand et al., 2011). Furthermore, Jung and colleagues (2009) found a small to moderate effect of combined exercise and education interventions (n=2) and a non-significant small effect for exercise only interventions (n=3), suggesting that combining education and exercise is more effective than exercise alone (Jung et

al., 2009). These studies indicate that different types of interventions can reduce FoF in older people, although often only small or moderate effects were found.

So far, interventions have been examined on a meta-level, i.e. they were labelled and analyzed according to their most prominent feature (e.g. cognitive behavioral approach, exercise, etc.). Less prominent features may contribute to the intervention effects as well. Interventions often include different components that are assumed to contribute towards the intervention effect, such as goal setting, self-monitoring, exercise and nutritional supplementation. Studying the effectiveness of such components seems relevant for optimizing interventions. Studies in other areas have shown that different intervention components contribute to the outcome. For example, for cancer patients the inclusion of social cognitive theory- based components like modelling of behavior, goal setting and help in setting realistic expectations, were beneficial to improve overall quality of life (Graves, 2003). Classifying interventions according to their intervention components, may provide insight into components that could be strengthened or removed to optimize interventions and achieve larger or prolonged effects (Vestjens et al., 2015). Components to effectively reduce FoF have not yet been studied. In the present systematic review and meta-analysis of randomized controlled trials (RCTs) with FoF as outcome, we explore the association between specific intervention components and the reduction of FoF among community-dwelling older people. All intervention types are included and control groups received either no intervention or usual care.

Materials and methods

The international prospective register of systematic reviews (PROSPERO) holds the protocol of this systematic review and meta-analysis, registration ID CRD42018080483. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used for the reporting of this review (Moher et al., 2009), see the supplementary files at the journal website. Other supplementary information is available in the appendices and on Open Science Framework (OSF), DOI: 10.17605/OSF.IO/SF67D.

Search strategy

On November 30th 2020, the databases CENTRAL, CINAHL, EMBASE, PsycINFO, and PubMed were searched for articles published after July 1st 2005. Publication date was not an eligibility criterion and the systematic review performed by Zijlstra and colleagues was used to identify articles that were published before July 1st 2005 (Zijlstra et al., 2007b). To supplement the current systematic search, three additional search strategies were employed to identify articles published before and after July 1st 2005. First, experts that recently published about falling or FoF were contacted. Second, reviews and meta-analyses primarily directed at FoF were screened for potentially relevant articles. Lastly, protocol papers that emerged from the search strategy were used to identify published articles. Searches were filtered to include only publications written in Dutch or English. Keywords relating to FoF, randomized controlled trials and older adults were combined with 'AND'. The full search strategy is available in Appendix A.

Study selection process

Eligibility criteria

Criteria have been reported in detail elsewhere (Kruisbrink et al., 2020). In short, to be included, articles had to report on the results of a RCT conducted in a non-institutionalized population with a mean age of ≥ 65 years. In addition, FoF had to be an outcome of the study and the control group could receive only usual care or nothing (including wait-list control). Articles were excluded when they were not written in English or Dutch or when they were aimed at populations with specific diseases or health conditions, such as Parkinson's or stroke. The reason for using language as a criterion in addition to using it as a search filter, was that abstracts are often in English and scientific databases do not always recognize other languages from full texts.

Title and abstract screening

Two reviewers (authors MK and GARZ*)* screened the first 200 titles and abstracts independently. The following order was used in checking titles and abstracts against eligibility criteria: design of the study, age of the included sample, living situation of the sample, health of the study participants, FoF as outcome and language. The percentage of agreement between reviewers on whether to look

at the full texts was 95.5%. A kappa of 0.67 suggested there was good interrater reliability (Higgins & Green, 2011a). Consequently, the remaining titles and abstracts were screened for eligibility by one reviewer (author MK). An article also advanced to the full text phase when doubt remained after reading the title and abstract. In addition, articles from the review by Zijlstra and colleagues (2007) were screened against eligibility criteria of the current study, because the current study has one additional criterion for the control group.

Full text screening

To screen full texts, the following order of checking against criteria was applied: language, design of the study, control group, age of the included sample, living situation of the sample, health of the study participants and FoF as outcome. One reviewer (author MK) screened all full texts. Studies were excluded when one or more criteria were not clear, e.g. if the age of the population was not reported. When doubt remained about inclusion, articles were discussed with a second reviewer (RC, GIJMK or GARZ) and agreement was reached.

Data extraction

Pairs of two reviewers extracted data independently with a data-extraction form (authors MK, RC, GIJMK, KD, KLC, DK, SI, GARZ). Reviewers were not involved in data extraction of articles in which they were involved as a co-author. The extraction form can be found online. Extracted information included bibliographic information and information about the study design, population, content of the intervention, FoF measures and results, and risk of bias. For about 25% of the articles identified in the first round of searching (12 articles), the content of the interventions was independently screened for intervention components by two reviewers (authors MK and GARZ). In this study, intervention components were defined as “content-related ingredients of an intervention that have the potential to causally influence outcomes.” (Kühne et al., 2015), Examples of intervention components are goal setting, feedback, home modification, hip protectors, tailoring, increase in difficulty and discussion. A coding scheme was developed based on intervention mapping, the behavior change technique (BCT) taxonomy and falls taxonomy (Eldredge et al., 2011; Lamb et al., 2011; Michie et al., 2013) , and refined in several rounds of consensus meetings. For an overview of the interventions components and

coding conditions, see the coding scheme in Appendix B. When the component was mentioned as part of the intervention, it was coded as 1 (present). If not, it was coded as 0 (not present). When intervention descriptions were unclear regarding the presence of a certain component, the component was coded as missing. Aspects belonging to usual care were not coded, meaning that only components that were unique to the intervention group were extracted. Remaining intervention texts were coded by one reviewer (author MK). In case of any ambiguity during the coding process, a second reviewer (RC, KD or GARZ) was consulted and agreement reached. Studies in which the intervention content was completely tailored and there was no clear indication of what participants could receive, were included in the overall meta-analysis but not in the meta-regressions (see below for the performed analyses). Results on FoF were extracted at two separate time points, i.e. the first and the last available assessment in the study at hand. Data were extracted for all intervention arms. We contacted authors when the data presented in an article was not suitable for meta-analysis, e.g. if results were presented in figures only. When the data could not be provided, the article was excluded for the meta-analysis. If a reference to a protocol or main study article was included in an article's intervention description, this reference was checked for additional information about the intervention. Selection bias (two items), performance bias, detection bias, attrition bias, reporting bias and other types of bias were assessed in a separate extraction form with the Cochrane Collaboration's Tool to assess risk of bias in RCTs (Higgins et al., 2011).

Analysis

The means, standard deviations (SD) and numbers of participants of the intervention and control group were used to estimate the standardized mean difference (SMD) in FoF for each study. Calculation of standardized effects is appropriate when different measures are pooled (Higgins & Green, 2011b). If regression coefficients representing mean differences between the intervention and control group were reported, these were used instead of follow-up means. Standard errors (SE) or 95 percent confidence intervals (95% CI) were used to calculate SDs if these were not reported. See the online material for an overview of the applied formulas. If appropriate, scales were inverted to make sure a high

score represented a high level of FoF. The following interpretation was used for the SMD: 0.2 is a small effect, 0.5 is a moderate effect and 0.8 is a large effect (Cohen, 1988).

We pooled SMDs at the first available follow-up after the intervention with random effects meta-analysis. We started with estimating main effects on FoF in an overall meta-analysis. Subsequently, we estimated associations between intervention components and the SMD at the first available follow-up with univariate meta-regression. The regression coefficient represents the difference in the SMD between interventions with (coded as 1) and without (coded as 0) the component in question. In case of multiple intervention arms, the intervention arm listed first in the article's abstract was the one used in the primary analyses. Statistical significance was set at $p<0.05$.

The following pre-specified sensitivity analyses were performed to investigate the robustness of the results and the methodological decisions: (I) using the other intervention arm of a study in meta-regressions, if more than one intervention arm was involved, (II) removing the cluster RCTs from the meta-regressions, (III) using the results of the latest assessment to perform meta-regressions, (IV) using study quality (the number of high risk bias items) as a continuous variable in a meta-regression, (V) restricting analyses to studies with the best study quality (2 high risk bias items), (VI) performing a separate meta-analysis on cognitive-based FoF measures (e.g., Falls Efficacy Scale (FES), Activities-specific Balance Confidence scale (ABC)) and affect-based FoF measures (e.g., Falls Efficacy Scale-International (FES-I), the Survey of Activities and Fear of Falling in the Elderly (SAFFE)), and (VII) removing outliers from the meta-regressions. Furthermore, two of our components deviated from the BCT and falls taxonomy and we performed sensitivity analysis in which we (VIII) combined the components 'support', 'motivational strategy – supervisor' and 'motivational strategy – peer', as is the case in the BCT taxonomy, and (IX) combined 'walking strategies' and 'balance', as is the case in the falls taxonomy. Lastly, we (X) combined the components 'assistive devices' and 'home adaptation', as home adaptations such as a grab bar could also be defined as an assistive device.

To assess statistical heterogeneity (an estimate of between study variation), I^2 and Q test statistics were used. The following interpretations from

the Cochrane handbook were used: "0% to 40%: might not be important; 30% to 60%: may represent moderate heterogeneity*; 50% to 90%: may represent substantial heterogeneity*; 75% to 100%: considerable heterogeneity *" (Higgins & Green, 2011c). We investigated components that could occur in a range of intervention types, e.g. in home visits, cognitive behavioral interventions or exercise interventions. As we pooled different types of interventions, we expected heterogeneity in the overall meta-analysis to be high. The intervention components could potentially explain some of the heterogeneity. Egger's test was used to statistically assess publication bias. In addition, funnel plots were visually inspected for publication bias. Outliers were determined by inspection of the forest and funnel plot. All analyses were performed with STATA version 15.

Results

Study selection

A flowchart of the study selection process is shown in Figure 1. A total of 12,551 unique records from five literature databases were screened. After screening the titles and abstracts and reading the full texts, 99 articles reporting on 66 unique trials could be included in the systematic review. The data of several studies (n=15) were unsuitable for inclusion in the meta-analyses because intervention descriptions or scales used to measure FoF were unclear, or means or SDs were missing and data could not be retrieved by estimation or contacting the author. Fifty-one studies with data on 52 intervention groups were included in meta-analysis.

Description of studies

A full description of included studies, including their designs, primary outcomes, sample characteristics and FoF measures is available online. Briefly, most studies were parallel group RCTs (n=57), but cluster RCTs (n=5) and crossover RCTS (n=4) were also present. Designs with three (n=15) or four (n=2) arms were included, but the majority of studies had two study arms (n=49). Twenty-one studies assessed FoF more than once after the intervention. The risk of bias scoring can be viewed online. In short, the number of high risk of bias items ranged from two to four out of the total of seven items. Due to the nature of the

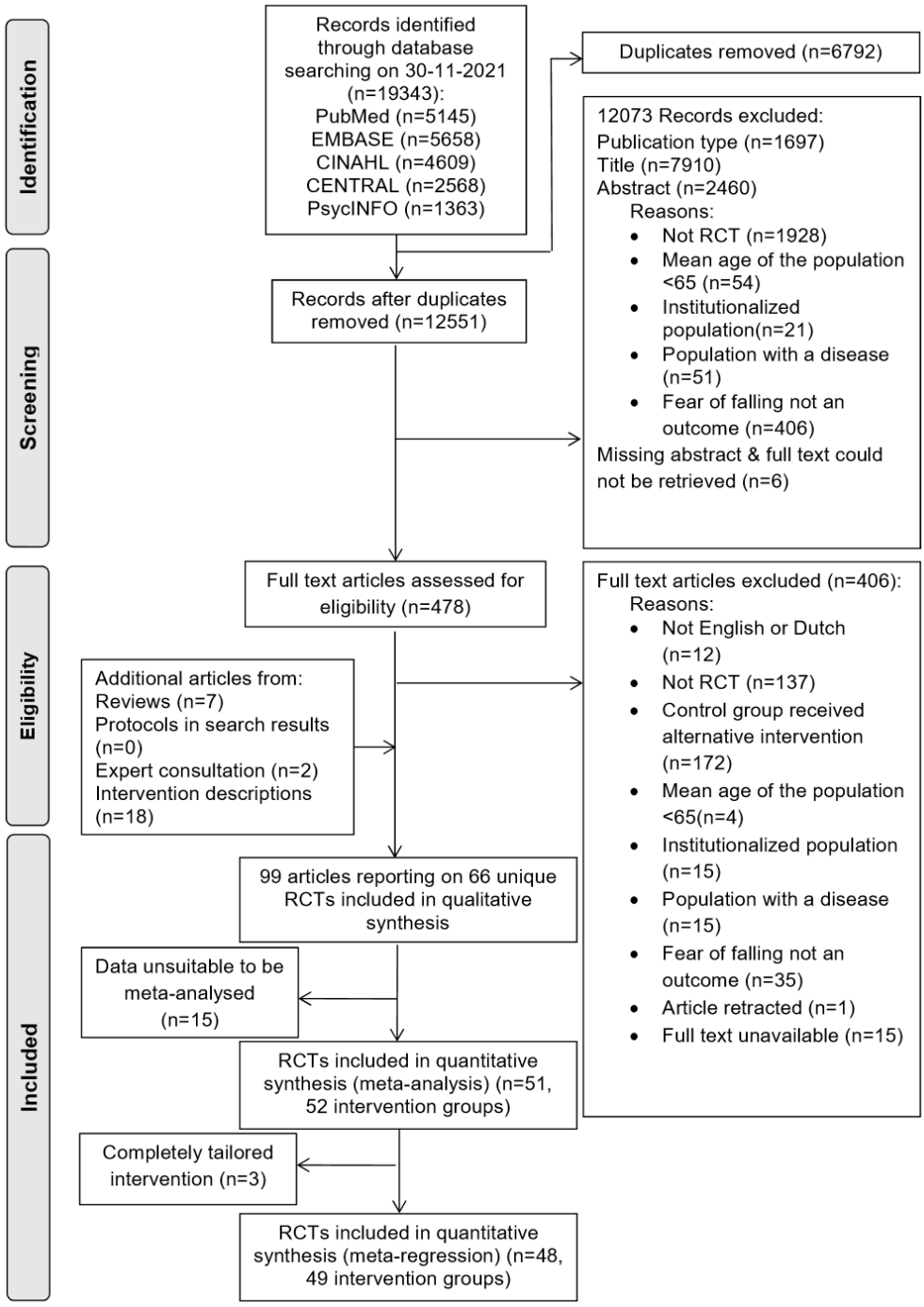

Figure 1. Flow-chart of study selection process. Adapted from Moher et al. (2009)

interventions, blinding was impossible and the two items regarding blinding of participants and personnel and outcome assessors (performance bias and detection bias) were always scored with a high risk of bias.

Description of components

Sixty-six studies reported on 85 interventions. See the online material for an overview of intervention components per intervention and Appendix B for a detailed description of intervention components. A total of 68 different components were identified. A mean of 11 components (range 2-46) was reported in the interventions. Great diversity of components was evident in the studies, such as discussion, education, balance exercises, strength exercises, graded tasks, relaxation, feedback, goal setting, diet, energy conservation, visualization and home adaptation. Components most frequently embedded in the interventions were balance exercises (n=35), an increase in difficulty (n=52), motivating the participants (n=29), repetition (n=80), strength training (n=39), tailoring (n=52) and a warm-up (n=30). Some components rarely occurred. For example, podiatry and feedback by peers only occurred twice and visualization and providing participants with hip protectors only occurred once. For three studies (Metzelthin et al., 2013; Snooks et al., 2017; van Haastregt et al., 2000), the content of the intervention was completely tailored to the individual and there was no clear indication of what participants received.

Meta-analysis

All interventions pooled together were associated with a small to moderate reduction in FoF at the first available follow-up after the intervention (Figure 2, SMD: -0.36. 95% CI: -0.48; -0.25. I^2: 78.7%, p<0.001. n=52). There was significant publication bias (p<0.001) and six outliers could be determined (Hafström et al., 2016; Hosseini et al., 2018; Mortazavi et al., 2018; Nguyen & Kruse, 2012; Nick et al., 2016; Pirauá et al., 2019). Without these six outliers, the remaining interventions were associated with a small reduction in FoF (SMD: -0.20. 95% CI: -0.28; -0.12. I^2: 52.3%. p<0.001. n=46). The overall estimates for cognitive-based and affect-based measures were similar (-0.37 and -0.36 respectively, sensitivity analysis VI). Additional results, such as the funnel plot and the forest plots for sensitivity analyses are available online.

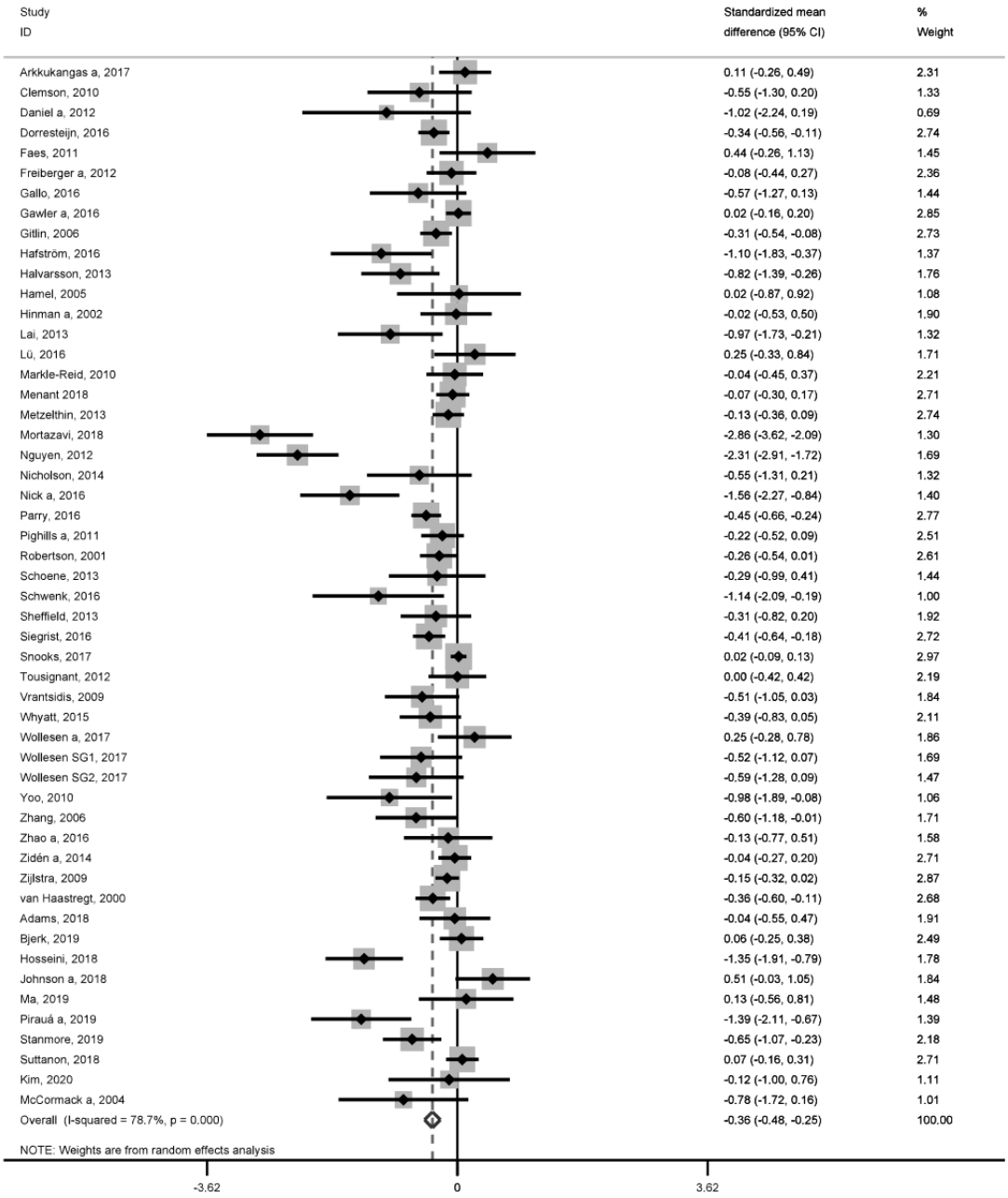

Figure 2. Forest plot of the 52 intervention arms included in the overall meta-analysis. A negative standardized mean difference implies a decrease in fear of falling. A positive standardized mean difference implies an increase in fear of falling.

Meta-regression

Of 68 components, 66 could be included in univariate meta-regressions. For the remaining two components, there were no studies with the component that could be included in the meta-regression. The univariate meta-regressions showed that most intervention components were not significantly associated with effects on FoF (see Table 1). Body awareness (B: -0.53. 95% CI: -0.93; -0.13. n=11 out of 49), holistic exercises (B: -0.67. 95% CI: -1.10; -0.24. n=9 out of 49) and meditation (B: -0.79. 95% CI: -1.35; -0.23. n=5 out of 49) were significantly associated with a decrease in the SMD, meaning they were more effective in reducing FoF than interventions without these components. The intervention components balance (B: 0.45. 95% CI: 0.11; 0.78. n=22 out of 49), self-monitoring (B: 0.44. 95% CI: 0.02; 0.86. n=10 out of 48) and tailoring (B: 0.52. 95% CI: 0.16; 0.87. n=28 out of 47) were significantly associated with an increase in the SMD. This indicates that interventions with these components were significantly less effective in reducing FoF than studies without these components. Bubble plots that visualize the results of the aforementioned significant components are available online.

Overall, our sensitivity analyses confirmed the robustness of the results (see the footnotes in Table 1 for an overview of results from sensitivity analyses). The changes that did occur mainly followed from repeating the meta-regressions with the results of the last assessment (sensitivity analysis III) and repeating meta-regressions without outliers (sensitivity analysis VII). When repeating meta-regressions with a smaller sample of 15 studies that measured FoF at a later time point, most previously mentioned significant associations disappear. For tailoring, this sensitivity analysis could not be performed due to a lack of studies without tailoring. When six outliers identified based on the funnel plot were removed, tailoring, self-monitoring, body-awareness, holistic exercises and meditation were no longer associated with the SMD. Study quality (sensitivity analysis IV) was not significantly associated with the SMD.

Table 1. Meta-regression results for intervention components for the first available follow-up after the intervention.

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
1	Assertiveness training	8, 66	421/2367	431/2242	0.18	0.41	0.657	-0.64	1.01	78.5
2	Assistive devices	10, 29, 46, 50	229/2391	233/2311	0.49	0.31	0.130	-0.15	1.12	77.9
3	Balance	1, 3a, 4, 6, 10, 11a, 12, 13a, 14, 15, 16, 21a, 29, 31, 42, 45, 47, 50, 55, 59a, 64a, 65a	1573/1215	1492/1181	0.45*	0.17	0.010 [b e f]	0.11	0.78	75.2
4	Behavioral activation	31, 37	301/2487	317/2356	0.17	0.41	0.690	-0.66	1.00	78.6
5	Body awareness	11a, 15, 33, 34, 36a, 47, 53, 55, 58, 63, 64a	479/2309	446/2227	-0.53*	0.20	0.010 [e g]	-0.93	-0.13	75.9
6	Booster	6	17/2046	12/1963	-0.13	0.69	0.847	-1.52	1.25	78.5
7	Cognitive processing	10, 34, 44, 47, 58, 59a, 60a, 60b, 64a	374/2414	317/2356	-0.03	0.23	0.881	-0.50	0.43	77.9

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
8	Cognitive restructuring	8, 10, 14, 31, 37, 47, 66	1062/1726	1038/1635	0.25	0.24	0.299	-0.23	0.73	78.5
9	Cool-down	11a, 13a, 16, 20, 27, 28, 30a, 34, 47, 62, 63, 64a	653/2135	636/2037	-0.19	0.21	0.369	-0.61	0.23	78.4
10	Daily task	1, 4, 10, 16, 21a, 31, 49, 55, 59a, 60a, 60b	478/2142	438/2106	0.32	0.21	0.141	-0.11	0.74	78.6
11	Demonstration of behavior	8, 10, 21a, 36a, 63	232/2388	254/2290	0.14	0.30	0.642	-0.46	0.75	78.8
12	Diet	29	49/2739	43/2630	0.39	0.60	0.523	-0.82	1.60	78.5
13	Discouraged	10	18/2770	15/2658	0.87	0.66	0.197	-0.46	2.20	78.2
14	Discussion	8, 10, 11a, 17, 29, 38a, 47, 65a, 66	985/1803	882/1791	0.38	0.22	0.086	-0.06	0.81	78.3
14.1	Discussion – Informal caregiver	10	18/2770	15/2658	0.87	0.66	0.197	-0.46	2.20	78.2
14.2	Discussion - Peer	10, 11a, 17, 47, 66	534/2254	476/2197	0.38	0.28	0.184	-0.19	0.96	78.5

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
14.3	Discussion - Supervisor	8, 10, 11a, 17, 29, 38a, 47, 65a, 66	985/1803	882/1791	0.38	0.22	0.086	-0.06	0.81	78.3
14.4	Discussion - Other	-	0/2788	0/2673	-	-	-	-	-	-
15	Education – Environmental fall risk factors	4, 8, 10, 29, 47, 50, 65a, 66	1038/1733	956/1696	0.43	0.22	0.056[d]	-0.01	0.88	78.0
16	Education – Physical fall risk factors	4, 8, 10, 29, 50, 60a, 60b, 65a, 66	920/1851	860/1792	0.38	0.22	0.087	-0.06	0.82	77.7
17	Education – Psychological fall risk factors	4, 8, 10, 29, 47, 50, 66	864/1907	842/1810	0.42	0.24	0.084	-0.06	0.89	78.5
18	Education – Other	6, 8, 10, 14, 29, 31, 46, 65a, 66	1001/1693	927/1647	0.36	0.22	0.114	-0.09	0.80	78.5
19	Endurance	1, 3a, 4, 7a, 10, 12, 13a, 21a, 42, 47, 59a, 60a, 60b, 62	815/1973	784/1889	0.35	0.19	0.073	-0.03	0.74	77.5

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
20	Energy conservation	14	154/2634	146/2527	0.11	0.58	0.847	-1.05	1.27	78.5
21	Exergames	19a, 24, 44, 49, 58	145/2643	147/2526	-0.04	0.30	0.892	-0.64	0.56	78.3
22	Exposure	8, 31, 37	442/2346	488/2185	0.14	0.34	0.681	-0.55	0.83	78.5
23	Fall recovery	1, 10, 14, 47	369/2402	320/2332	0.33	0.31	0.296	-0.30	0.97	79.0
24	Feedback	6, 10, 24, 44, 45, 49, 58, 60a, 60b	213/2538	186/2452	-0.11	0.24	0.641[g]	-0.60	0.38	78.3
24.1	Feedback - Device	24, 44, 45, 49, 58	128/2623	126/2512	-0.27	0.31	0.381[g]	-0.89	0.35	78.2
24.2	Feedback - Peer	10	18/2733	15/2623	0.86	0.67	0.204	-0.48	2.20	78.6
24.3	Feedback - Supervisor	6, 10, 58, 60a, 60b	123/2628	102/2536	0.09	0.31	0.771	-0.53	0.71	78.9
24.4	Feedback - Other	10	18/2733	15/2623	0.86	0.67	0.204	-0.48	2.20	78.6
25	Flexibility	1, 7a, 11a, 13a, 21a, 30a, 47, 64a, 66	821/1967	800/1873	0.31	0.23	0.181	-0.15	0.76	77.7
26	Generalization	14	154/2634	146/2527	0.11	0.58	0.847	-1.05	1.27	78.5
27	Goal setting	6, 8, 10, 29, 37, 38a, 46, 47, 49, 66	1004/1617	960/1545	0.19	0.22	0.402	-0.26	0.63	79.2

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
28	Hip protector	29	49/2739	43/2630	0.39	0.60	0.523	-0.82	1.60	78.5
29	Holistic (e.g. Tai Chi, yoga, Pilates and Ving Tsun)	1, 20, 28, 33, 34, 35, 36a, 53, 63	245/2543	236/2437	-0.67*	0.21	0.003[b e g]	-1.10	-0.24	74.5
30	Home adaptation	8, 14, 29, 38a, 46, 50, 66	873/1915	873/1800	0.28	0.24	0.242	-0.20	0.76	78.3
31	Home care	29	49/2739	43/2630	0.39	0.60	0.523	-0.82	1.60	78.5
32	Home screening	8, 10, 14, 29, 38a, 46, 50, 65a, 66	1065/1723	1002/1671	0.38	0.21	0.078	-0.04	0.81	77.8
33	Incontinence	29	49/2739	43/2630	0.39	0.60	0.523	-0.82	1.60	78.5
34	Increase in difficulty	1, 3a, 4, 6, 7a, 10, 11a, 13a, 15, 16, 19a, 20, 21a, 22, 27, 28, 31, 35, 36a, 37, 39a, 42, 44, 45, 47, 49, 58, 59a, 60a, 60b, 64a	1516/1272	1467/1206	0.20	0.18	0.290	-0.17	0.57	78.5

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
35	Integration into daily life	1, 6	46/2742	42/2631	0.16	0.47	0.740	-0.78	1.10	78.6
36	Mastery	6, 10, 15, 17, 24, 27, 31, 35, 42, 44, 47, 63	572/2169	503/2119	0.10	0.21	0.650	-0.33	0.52	77.9
37	Medicine modification	29, 31, 46, 65a	391/2397	323/2350	0.34	0.30	0.268	-0.27	0.95	77.9
38	Meditation	20, 34, 35, 36a, 53	148/2640	141/2532	-0.79*	0.28	0.007[b e g]	-1.35	-0.23	75.0
39	Modelling	8, 10, 31	296/2492	323/2350	0.41	0.35	0.249	-0.30	1.18	78.5
40	Motivational interviewing	8, 29	190/2598	214/2459	0.23	0.42	0.585	-0.62	1.08	78.6
41	Motivational strategy	4, 8, 10, 12, 13a, 15, 17, 21a, 30a, 31, 35, 36a, 42, 44, 45, 49, 58, 59a, 65a, 66	1422/1212	1376/1151	0.23	0.18	0.222	-0.14	0.60	77.8
41.1	Motivational strategy – informal caregiver	10	18/2616	15/2512	0.87	0.67	0.199	-0.47	2.21	78.6

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
41.2	Motivational strategy - device	45, 49, 58	98/2536	94/2433	-0.27	0.38	0.482[g]	-1.04	0.50	78.5
41.3	Motivational strategy - peer	10, 13a	239/2395	273/2254	0.64	0.43	0.149	-0.24	1.51	77.8
41.4	Motivational strategy - supervisor	4, 8, 10, 12, 13a, 17, 21a, 30a, 31, 35, 36a, 42, 44, 59a, 65a, 66	1304/1330	1268/1259	0.37	0.19	0.054[b c g]	-0.01	0.74	76.7
41.5	Motivational strategy - other	8, 15, 44	176/2458	202/2325	-0.13	0.38	0.725	-0.90	0.63	78.8
42	Motor coordination	10, 11a, 15, 20, 44, 45, 47, 49, 59a, 63, 64a	437/2351	391/2282	-0.03	0.22	0.885	-0.47	0.41	78.0
43	Multitasking	10, 12, 16, 22, 27, 44, 47, 58, 59a, 60a, 60b	397/2391	338/2335	0.20	0.22	0.361	-0.24	0.64	78.5
44	Option for additional personal assistance	4, 10, 11a, 14, 17, 31, 42, 44, 47, 50	877/1911	837/1836	0.41	0.21	0.055[b d]	-0.01	0.82	78.0

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
45	Peer interaction	1, 10, 11a, 13a, 16, 17, 47, 66	818/1970	785/1888	0.33	0.23	0.161	-0.14	0.80	77.9
46	Perceptual training[i]	47,	168/2620	129/2544	0.01	0.58	0.990	-1.15	1.17	78.4
47	Persuasion	-	0/2634	0/2527	-	-	-	-	-	-
48	Podiatry	29, 50	180/2608	189/2484	0.46	0.42	0.278	-0.38	1.29	77.7
49	Problem solving	8, 10, 14, 29, 37, 38a, 65a, 66	1067/1721	1007/1666	0.32	0.22	0.164	-0.13	0.77	78.5
50	Referral	29, 31, 38a, 65a	447/2264	372/2223	0.38	0.30	0.218	-0.23	0.98	77.9
51	Reflection	10, 37, 66	462/2326	455/2218	0.34	0.35	0.345	-0.37	1.04	78.6
52	Reinforcement[i]	6, 12, 14, 21a, 31	350/2438	343/2330	0.27	0.29	0.355	-0.31	0.85	78.4
53	Relaxation	17, 35, 36a, 53	91/2697	85/2588	-0.10	0.35	0.781	-0.79	0.60	78.5
54	Reminder	1, 6, 10, 13a, 31	422/2366	452/2221	0.43	0.28	0.138	-0.14	1.00	77.1
55	Repetition	1, 3a, 4, 6, 7a, 8, 10, 11a, 12, 13a, 14, 15, 16, 17, 19a, 20, 21a, 22, 24, 27, 28, 29, 30a, 31, 33, 34, 35,	2614/174	2559/114	-0.39	0.57	0.501	-1.54	0.77	78.2

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
		36a, 37, 38a, 39a, 42, 44, 45, 46, 47, 49, 50, 53, 55, 58, 59a, 60a, 60b, 62, 63, 64a, 66								
56	Safety	4, 6, 10, 11a, 14, 15, 19a, 44, 45, 47, 58, 66	882/1906	816/1857	0.16	0.21	0.430	-0.25	0.58	78.5
57	Self-monitoring	3a, 4, 6, 8, 10, 12, 21a, 31, 37, 50	781/1898	842/1734	0.44*	0.21	0.039 [c e f g]	0.02	0.86	78.3
58	Shared decision making	6, 29, 37, 38a, 46	348/2440	342/2331	0.13	0.29	0.657	-0.45	0.70	78.4
58.1	Shared decision making - Supervisor	6, 37, 38a, 46	299/2489	299/2374	0.05	0.32	0.876	-0.59	0.69	78.3
58.2	Shared decision making - Other	29, 46	80/2708	72/2601	0.26	0.44	0.558	-0.62	1.14	78.5
59	Sleep management	37	164/2624	180/2493	-0.03	0.58	0.953	-1.19	1.12	78.2

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
60	Strength	1, 3a, 4, 6, 7a, 10, 11a, 12, 13a, 14, 15, 20, 21a, 27, 29, 30a, 31, 39a, 42, 47, 50, 62, 64a, 66	1688/1100	1642/1031	0.29	0.17	0.098 [f g]	-0.06	0.64	76.3
61	Summarizing	10, 31, 38a	242/2546	230/2443	0.46	0.35	0.196	-0.25	1.17	78.2
62	Support	1, 3a, 8, 10, 13a, 16, 21a, 29, 31, 45, 46	754/2034	794/1879	0.38	0.20	0.069 [h]	-0.03	0.79	77.2
62.1	Support - Peer	13a, 16	255/2533	279/2394	0.06	0.43	0.886	-0.80	0.93	78.1
62.2	Support - Supervisor	3a, 8, 13a, 16, 21a, 29, 31, 45	676/2112	720/1953	0.30	0.23	0.207	-0.17	0.76	77.5
62.3	Support - Others	1, 8, 10, 29, 46	268/2299	288/2127	0.39	0.29	0.179	-0.19	0.96	78.0
63	Tailoring	1, 3a, 4, 6, 8, 10, 11a, 12, 13a, 14, 16, 27, 29, 31, 37, 38a, 39a, 42, 44, 46, 47, 49, 50, 53, 58, 62, 65a, 66	2348/413	2279/363	0.52*	0.18	0.006[g]	0.16	0.87	75.4

	Component[a]	Studies with component	n yes/ n no (intervention)[b]	n yes/ n no (control)	regression coefficient (change in SMD)	SE	P-value	CI low	CI high	Heterogeneity (I2, %)
64	Vestibular	15, 31, 64a	174/2614	172/2501	0.04	0.37	0.924	-0.72	0.79	78.5
65	Visual	29	49/2739	43/2630	0.39	0.60	0.523	-0.82	1.60	78.5
66	Visualization	17	12/2776	8/2665	0.45	0.73	0.545	-1.03	1.92	78.5
67	Walking strategies	1, 6, 10, 11a, 12, 45, 47, 59a, 60a, 60b, 64a	408/2346	361/2291	0.17	0.22	0.449	-0.27	0.61	78.6
68	Warm-up	4, 11a, 13a, 15, 16, 19a, 20, 27, 28, 30a, 34, 36a, 47, 62, 63, 64a	798/1990	777/1896	-0.22	0.19	0.262	-0.60	0.17	78.4

[a] See Appendix B for a detailed description of intervention components and Appendix C for the citations belonging to the study numbers.
[b] Significance changes in sensitivity analysis I, when repeating the meta-regressions with the second intervention arm of a study.
[c] Significance changes in sensitivity analysis I, when repeating the meta-regressions with the third intervention arm of a study
[d] Significance changes in sensitivity analysis II, when removing cluster RCTs from the analysis.
[e] Significance changes in sensitivity analysis III, when performing meta-regressions with the results of the latest available assessment.
f Significance changes in sensitivity analysis V, when restricting analyses to studies with the best study quality (2 high risk bias items).
[g] Significance changes in sensitivity analysis VII, when removing outliers from the meta-regressions.
[h] Significance changes in sensitivity analysis VIII, combining support and motivation.
[i] Intervention components that were distinguishable from intervention texts, but insufficiently explained to know what was meant for certain.
** P<0.05*

Discussion

Overall, the interventions in our meta-analysis (n=52) resulted in a small to moderate reduction in FoF in community-dwelling older people (SMD: -0.36 [95% CI: -0.48; -0.25]). We explored the content of interventions, as a first step to gaining insight into the contribution of specific components to this reduction. We identified 68 different components, of which 66 could be included in univariate meta-regressions. Most of these intervention components were not associated with an intervention effect on FoF. However, interventions with body awareness exercises, holistic exercises or meditation were significantly more effective in reducing FoF than interventions without these components. In contrast, interventions with balance training, self-monitoring or tailoring were significantly less effective in reducing FoF than interventions that did not include these components. Considering long-term effectiveness, only 15 interventions in our meta-regressions included more than one follow-up. When we analyzed these studies, most previously mentioned components were no longer significant. However, it is likely this analysis was underpowered and therefore, long-term effects are still uncertain. Other sensitivity analyses generally confirmed the robustness of these results. When six outliers identified based on the funnel plot were removed, a different pattern of associations appeared in which tailoring, self-monitoring, body-awareness exercises, holistic exercises and meditation were no longer identified as significant. However, four of the six outliers were highly effective studies of holistic exercise interventions, often including elements of body awareness and meditation, but not self-monitoring or tailoring. As the associations disappear when these effective studies are removed, this could indicate that holistic exercise, body awareness and meditation are among the most effective components to reduce FoF. The intervention studies included in our meta-analysis consistently scored a high risk of bias on two items, regarding blinding of participants and personnel (performance bias) and outcome assessment (detection bias). It is worthwhile to stress that it is very difficult to achieve blinding in these kind of studies (in comparison with, for example, pharmacological trials) (Boutron et al., 2004). Furthermore, when participants are aware of their group allocation and

outcome measurement is based on self-report, the potential for detection bias is high.

To the best of our knowledge, no previous meta-analyses have examined the content of interventions on the level of components for the outcome FoF. Usually, the content of interventions is classified according to their most prominent feature. Rand and colleagues (Rand et al., 2011) conducted a meta-analysis of 24 studies and found larger effects on FoF for Tai Chi than for other exercise interventions or multifactorial interventions, which is in line with the findings of the current study. Kendrick and colleagues (Kendrick et al., 2014) found no significant differences in effect on FoF by exercise type in their meta-analysis of 24 exercise interventions. This difference in results with the current study may be due to differences in analysis methods and eligibility criteria or the inclusion of more recent studies, such as the study by Mortazavi and colleagues (Mortazavi et al., 2018), presenting a highly effective Tai Chi intervention.

Several findings that may be relevant to current practice are observed. First, in falls prevention, balance training and tailoring are generally considered as beneficial (Gillespie et al., 2012; Sherrington et al., 2019; Yardley et al., 2006; Yardley & Nyman, 2007). However, in the current study, interventions including balance training or tailoring were less effective for reducing FoF compared to interventions that did not include these components. Second, self-monitoring was less effective in the current study, while self-monitoring has previously demonstrated effectiveness for a range of health behaviors, including taking up exercise (Michie et al., 2009). There may be several reasons for these apparent inconsistencies. Falls and FoF are different concepts that may require different treatments with different intervention components, i.e**.** effective intervention components may differ for FoF and falls risk. For instance, tailoring could help older people become more aware of their fall risk, which can be beneficial for the intention to participate in fall prevention programs (Hill et al., 2013; Yardley & Nyman, 2007), but may not be beneficial for fear of falling. In a qualitative study, some persons with Parkinson's disease, indicated the awareness of their risk of falling increased their FoF (Jonasson et al., 2018). Furthermore, without returning to 'multicomponent' interventions, it may be possible that analyzing a combination of two or more components may provide more insight.

Combinations of components may be required to reduce FoF. For instance, balance exercises may need to be offered in combination with cognitive restructuring in order to reduce FoF or repetition may be beneficial for exercise, but not for discussion. The theoretical underpinning required to formulate hypotheses and to investigate combinations with standard meta-regression techniques is lacking so far. Other data-driven techniques, like Meta-CART, require sufficient data for the intervention components under study (Li et al., 2017). The current meta-analysis lacked sufficient data for some components. Lastly, other aspects of interventions and their effect on FoF may need to be taken into account. For example, for FoF, interventions may need to be longer, for participants not only to master skills, but also to gain confidence by incorporating these skills in daily life.

The strengths of the current study include its systematic survey of five scientific databases, rigorous quality assessment and its detailed overview of intervention components. This study was also subject to several limitations, leading to recommendations for future research. First of all, because of the diversity of interventions that included FoF as an outcome, there were no suitable pre-existing overall taxonomies that could be used in coding our components. Therefore, our components guide was tailor made to suit our study and future studies may provide additional validation. Furthermore, we considered this an exploratory study and we did not use a correction for multiple testing. This may have caused a risk of type 1 error. Moreover, we came across a large variation in the level of detail of intervention descriptions and some interventions reported only a few main components. It is possible that some interventions did not report on the presence of certain components, causing bias in the results. For example, studies often did not report whether the desired behavior was demonstrated. Reporting in the included studies was also not detailed enough to determine the delivered dose or actual compliance with the intervention, hence we only considered planned delivery of components. Future studies should include detailed reporting on intervention content and actual delivery to facilitate future meta-analyses, for example by following the TiDieR checklist (Hoffmann et al., 2014). An approach like intervention component analysis (ICA, (Sutcliffe et al., 2015)) may also be considered. The informal evidence that is taken into account in ICA, may reveal components that are not

included in intervention descriptions. In addition, some intervention components rarely occurred in our sample of studies and power may have been lacking in our analyses. For example, only one study included the intervention component visualization. Future studies on such components are necessary to properly investigate their effectiveness with meta-analysis. Furthermore, the components identified as promising in the current study can be used to develop or adapt interventions and to accumulate more evidence on these components. For example, the type of tailoring may be investigated (Schepens et al., 2011). Lastly, a strong theoretical rationale about intervention components and characteristics - and their interaction - is required to formulate hypothesis that can be tested with multivariate meta-regression techniques.

Conclusion

Our analyses indicate that interventions with body awareness, holistic exercises and meditation were more effective than interventions without these components. Interventions with tailoring, motivation by the supervisor, balance exercises or self-monitoring were less effective than interventions without these components. These components may be emphasized or de-emphasized, respectively, when designing or optimizing interventions to reduce FoF, in order to prevent its disabling consequences in community-dwelling older people. Clinicians should consider including these components in their treatments for fear of falling, also taking into account costs and culture.

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Disclosure statement

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Data availability statement

The data that support the findings of this study are openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/SF67D.

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Appendix A – Search strategy

This appendix contains the search strategy for PubMed. For the search strategy in EMBASE, PsycINFO, CINAHL and CENTRAL, please see the online Open Science Framework project.

PubMed

Search number	Query
#1	(((fear OR fearing OR fearful OR Fear[mh] OR anxiety OR anxious OR frightened OR concern OR concerns OR concerned OR afraid OR worry OR worries OR worrying OR worried OR confidence OR confident OR (self AND efficacy) OR self-efficacy) AND (fall OR falls OR falling OR fall-related OR balance OR Accidental Falls [mh])) OR balance-confidence OR (("FOF" AND (scale OR likert OR item OR items)) OR ((psychological OR psychosocial) AND (fall OR falls OR falling OR fall-related)) OR "falls efficacy scale" OR "falls efficacy scale international" OR "FES-I" OR "FES-NL" OR "FES-UK" OR (("FES" OR "rFES" OR "moFES" OR "mFES" OR "aFES" OR "amFES") AND (fall OR falls OR falling OR fall-related)) OR "fear of falling questionnaire" OR (("FFQ-R" OR "FFQ") AND (fall OR falls OR falling OR fall-related)) OR "activities specific balance confidence scale" OR "ABC-NL" OR "ABC-UK" OR ("ABC" AND (fall OR falls OR falling OR fall-related)) OR "mobility efficacy scale" OR ("MES" AND (fall OR falls OR falling OR fall-related OR mobility)) OR "survey of activities and fear of falling in the elderly" OR "SAFFE" OR ("SAFE" AND (fall OR falls OR falling OR fall-related)) OR "mSAFFE" OR "university of Illinois at Chicago fear of falling measure" OR "UICFFM" OR "UIC-FFM" OR "UIC FFM" OR "confidence in maintaining balance scale" OR "CONFbal" OR "geriatric fear of falling measurement" OR "GFFM" OR "concern about falling scale" OR ("CaF" AND (fall OR falls OR falling OR fall-related)) OR "falls handicap inventory" OR ("FHI" AND (fall OR falls OR falling OR fall-related)) OR "consequences of falling scale" OR ("CoF" AND (fall OR falls OR

	falling OR fall-related)) OR "concern about consequences of falling scale" OR "CONSfall"))
#2 Cochrane filter for RCTs (Cochrane Reviews, n.d.)*	((randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR randomised[tiab] OR placebo[tiab] OR drug therapy[sh] OR randomly[tiab] OR trial[tiab] OR groups[tiab] NOT (animals [mh] NOT humans [mh])) OR "Randomized Controlled Trials as Topic"[mh])
#3	((Aged[mh] OR ((aged OR age) AND 65) OR ((old OR older) AND (65 OR adult OR adults OR person OR persons OR men OR women OR people)) OR geriatric OR geriatrics OR senior OR seniors OR elderly))
#4	(#1 AND #2 AND #3)
#5	(#4) AND ("2005/07/01"[Date - Entrez] : "3000"[Date - Entrez])
#6	(#4) AND ("2005/07/01"[Date - Entrez] : "3000"[Date - Entrez]) Filters: English; Dutch

*Cochrane Reviews. (n.d.). *The Cochrane highly sensitive search strategies for identifying randomized trials in PubMed*. Retrieved 13-05-2019 from https://work.cochrane.org/pubmed

Appendix B – Components guide

Table 1. Coding scheme: Intervention components and coding conditions.

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
1	Assertiveness training	Participants practice standing up for themselves.
2	Assistive devices	Participants are offered an assistive device such as a walking stick, personal emergency response device or aid to put on compression stockings, or receive training in the use of assistive devices.
3	Balance	Physical exercises in which the bodyweight is shifted from one part of the body to another, including postural exercises. The balance exercises can be static (e.g. standing on one leg or tandem standing) or dynamic (e.g. knee bends, calf raises, toe raises). Balance exercise are often included in holistic exercise, such as Tai Chi or yoga. However, this balance component is not always mentioned in the articles about holistic interventions. There are many cases of suspected underreporting. In contrast, we also cannot assume that every holistic exercise intervention includes a balance component. Furthermore, it can be argued that the balance exercises offered during - for example - a Tai Chi class are different from conventional balance exercises. Therefore, we have decided to keep balance exercises and holistic exercises completely separate. This entails that if balance was mentioned as part of a holistic intervention, it was not coded as present ("1") for balance, but only for holistic.
4	Behavioral activation	Type of therapy that focusses on becoming more active and engaged in activities and reducing avoidance behaviors in order to increase positive reinforcement from the environment.
5	Body awareness	Exercises aiming to improve internal understanding of the position of the body in space

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
		or internal awareness of bodily sensations and the physical condition (e.g. Feldenkrais).
6	Booster	An intervention session in which intervention content is reinforced, reviewed or refreshed after the main content of intervention has been addressed.
7	Cognitive processing	Cognitive processes are trained, such as concentration, executive functioning, information processing, inhibitory response, selective attention, short-term memory, spatio-temporal orientation, visio-spatial capacities, task prioritization, switching between tasks, switching attention between tasks. Does not include higher cognitive functions such as thinking.
8	Cognitive restructuring	The identification and challenging of irrational or maladaptive thoughts. Cognitive restructuring is used in cognitive behavioral therapy.
9	Cool-down	Exercises to gradually bring the body into a resting state, such as stretching and relaxation exercises.
10	Daily task	Participants do physical exercises based on tasks from daily life, such as getting up from a chair or climbing stairs.
11	Demonstration of behavior	The desired behavior is demonstrated.
12	Diet	The diet of the participant is changed or supplemented.
13	Discouraged	Participants are discouraged from performing certain behaviors.
14	Discussion	Participants engage in a verbal exchange of information or experiences (not related to the procedures of the study) with other people.
14.1	Discussion – Informal caregiver	Discussion with the informal caregiver, i.e. the person participating in the care of the older adult
14.2	Discussion - Peer	Discussion with peers, i.e. with other participants in the intervention group or someone who is similar to the participant in another way, such as age or profession.

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
14.3	Discussion - Supervisor	Discussion with supervisor, i.e. with the person who delivers the intervention to the participant.
14.4	Discussion - Other	Discussion with another person, such as a family member.
	Education	Providing information or advice to participants, not including specific instruction (e.g. instruction on physical exercises or use of an assistive device).
15	Education – Environmental fall risk factors	Education about external factors related to falls, such as possible tripping hazards in the home environment.
16	Education – Physical fall risk factors	Education about physical factors related to falls, such as muscle strength and malnutrition.
17	Education – Psychological fall risk factors	Education about psychological factors related to falls, such as attitudes, thoughts, behavior, fear of falling, falls self-efficacy, depression or anxiety.
18	Education – Other	Education about other topics, such as local resources related to independent living and potential consequences of falls.
19	Endurance	Physical exercises that increase the heart rate, sometimes described as cardiovascular or aerobic exercises, such as walking and cycling.
20	Energy conservation	Participants practice strategies to preserve energy during the execution of functional tasks or activities of daily living.
21	Exergames	Physical exercises delivered through video games, such as Wii Fit. The physical exercises are combined as a group despite their actual content.
22	Exposure	Participants are exposed to fearful situations or a task that they previously avoided, either in real life or through virtual reality.
23	Fall recovery	Participants practice techniques to get up from the floor after a fall or to reduce complications from a long lie.
24	Feedback	Participants receive external information on their behavior or performance.
24.1	Feedback - Device	Participants receive feedback from a device, such as a score from a video-game or a pedometer.

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
24.2	Feedback - Peer	Participants receive feedback from peers, i.e. other participants in the intervention group or someone who is similar to the participant in another way, such as age or profession.
24.3	Feedback - Supervisor	Participants receive feedback from a supervisor, i.e. the person who delivers the intervention to the participant.
24.4	Feedback - Other	Participants receive feedback from another person, such as a family member.
25	Flexibility	Stretching exercises to improve or maintain range of motion. Flexibility exercises as part of holistic exercise is not coded. For an explanation, see component 3 'Balance'.
26	Generalization	Generalization of learned skills, strategies and insights to other problem areas.
27	Goal setting	Setting objectives regarding desired outcomes, physiological states, behavior or thoughts, including behavioral contracts and action plans.
28	Hip protector	Participants receive a hip protector to diminish the chance of hip fracture from falling.
29	Holistic	Yoga, Tai Chi, Pilates or Ving Tsun. Following the falls taxonomy (Lamb et al., 2011)*, the physical exercises are combined as a group.
30	Home adaptation	Modification of the home or physical environment to reduce the risk of falls, such as the instalment of grab bars or stair lift.
31	Home care	Participants receive assistance with ADL activities or healthcare.
32	Home screening	Screening to identify risk factors for falls in the participant's home or physical environment.
33	Incontinence	Treatment of underlying causes of incontinence.
34	Increase in difficulty	As part of the intervention, activities are increasingly more challenging, such as increases in complexity, speed, resistance, weight or duration.

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
35	Integration into daily life	Physical exercises that are integrated into daily life, such as rising up on the toes during brushing your teeth.
36	Mastery	Participants perform a certain behavior until they become skilled at it.
37	Medicine modification	Adjusting medications to reduce potential negative side effects for participants, such as dizziness.
38	Meditation	Participants practice focusing the mind and attention to achieve a mentally clear or emotionally calm and stable state.
39	Modelling	Modelling of the desired behavior, through the actual presence of a role model or through video.
40	Motivational interviewing	Interviewing technique that uses open questions, affirmations, reflective listening and summarizing to resolve ambivalence or uncertainty and lower resistance to change. After which participants make their own choices through intrinsic motivation.
41	Motivational strategy	Strategies that are used to encourage or motivate the participant.
41.1	Motivational strategy - caregiver	Participants are motivated by an informal caregiver.
41.2	Motivational strategy - device	Participants are motivated by a device, such as a pedometer or wii fit balance game.
41.3	Motivational strategy - peer	Participants are encouraged by peers
41.4	Motivational strategy - supervisor	Participants are encouraged by the supervisor
41.5	Motivational strategy - other	Participants are motivated by feedback from own bodies, self-monitoring, action plans, playing a role in development of the intervention or by a modelling dvd.
42	Motor coordination	Exercises aimed at improving motor coordination, including hand eye coordination.

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
43	Multitasking	Participants perform multiple tasks at the same time. These tasks can vary in nature, such as an obstacle course combining two or more cognitive tasks or a cognitive and a motor task etc.
44	Option for additional personal assistance	Participants have the option to ask personal questions, discuss problems or to seek additional personal instruction, not normally included in the intervention.
45	Peer interaction	Explicit interaction with other participants or someone who is similar to the participant in another way, such as age or profession. Includes socializing.
46	Perceptual training	Perceptual training
47	Persuasion	Using persuasive statements to convince participants.
48	Podiatry	Tailored advice regarding footwear or an appointment with a podiatrist.
49	Problem solving	Participants practice strategies to effectively solve problems, such as analyzing situations, generating multiple potential solutions and prioritizing solutions.
50	Referral	Participants are offered the option to attend any service provided in the community (not already embedded in the intervention), such as a pharmacist, an occupational therapist or a provider of assistive devices. The participant has to receive more than only information about available services.
51	Reflection	Participants evaluate or reflect on the program, their own performance or other issues.
52	Reinforce	Reinforcement
53	Relaxation	Exercises to help participants achieve a state of being free of physical or mental tension and anxiety.

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
54	Reminder	Signals to prompt participants to start with intervention activities.
55	Repetition	Repetition of (a part of) an intervention activity, such as a physical exercise, functional task or creating an action plan.
56	Safety	Participants are given explicit advice about safety precautions during exercise or specific measures are taken to ensure the safety of the participant during exercise, such as a safety platform or gait belt.
57	Self-monitoring	Participants keep track of outcomes, physiological states, behavior or thoughts as part of the intervention.
58	Shared decision making	Decision making process in which the participant agrees on intervention targets together with another person.
58.1	Shared decision making - Supervisor	Shared decision making with the supervisor, i.e. the person who delivers the intervention to the participant.
58.2	Shared decision making - Other	Shared decision making with another person, such as a family member.
59	Sleep management	Participants receive training in ways to achieve good quality and quantity of sleep.
60	Strength	Physical exercises in which the muscles contract against an external force. Often described as strength training, weight training, resistance training or bone loading. Including high velocity and momentum based strength training, walking with ankle weights and exergames with weighted vests. Strength exercises as part of holistic exercise is not coded. For an explanation, see component 3 'Balance'.
61	Summarizing	Information is summarized for the participant.

	Intervention component	Condition – intervention component is coded as present if the intervention description includes:
62	Support	Participants receive support as part of the intervention (e.g. emotional support like showing empathy or concern, or instrumental support like helping participants change the home environment).
62.1	Support - Peer	Participants receive support from peers, i.e. other participants in the intervention group or someone who is similar to the participant in another way, such as age or profession.
62.2	Support -Supervisor	Participants receive support from the supervisor, i.e. the person who delivers the intervention to the participant.
62.3	Support - Others	Participants receive support from others, such as a family member.
63	Tailoring	As part of a formal or informal assessment by a facilitator, the intervention is adapted to participants (not an adaptation solely based on the judgement of the participant).
64	Vestibular	Therapies to improve vestibular function or alleviate symptoms of vestibular disorders, such as dizziness.
65	Visual	The vision of participants is checked by an optometrist and appropriate action is taken.
66	Visualization	Participants imagine (motor) tasks, without actually performing it.
67	Walking strategies	Physical exercises focusing on the gait and walking strategies, such as stop-go, walking with turns, stepping over obstacles etc.
68	Warm-up	Exercises to prepare the body for exercise.

*Lamb, S. E., Becker, C., Gillespie, L. D., Smith, J. L., Finnegan, S., Potter, R., . . . Taxonomy, I. (2011). Reporting of complex interventions in clinical trials: development of a taxonomy to classify and describe fall-prevention interventions. *Trials*, *12*(1), 125. https://doi.org/10.1186/1745-6215-12-125

Appendix C – References of included studies

Table 1. References of included studies.

First author, year	Citation	Study number (Table 1 main document)
Adams, 2019	(Adams et al., 2018; Skelton et al., 2016)	1
Arghavani, 2020	(Arghavani et al., 2020)	2a, 2b
Arkkukangas, 2017	(Arkkukangas et al., 2020; Arkkukangas et al., 2017; Tuvemo Johnson et al., 2021)	3a, 3b
Bjerk, 2019	(Bjerk et al., 2019a; Bjerk et al., 2019b; Bjerk et al., 2017; Bjerk et al., 2019c)	4
Chang, 2011	(Chang et al., 2011)	5
Clemson, 2010	(Clemson et al., 2010)	6
Daniel , 2012	(Daniel, 2012)	7a, 7b
Dorresteijn, 2016	(Dorresteijn et al., 2016; Dorresteijn et al., 2011; Evers et al., 2020)	8
Duque, 2013	(Duque et al., 2013)	9
Faes, 2011	(Faes et al., 2011)	10
Freiberger, 2012	(Freiberger et al., 2012)	11a, 11b, 11c
Gallo, 2016	(Gallo et al., 2016)	12
Gawler, 2016	(Gawler et al., 2016; Iliffe et al., 2015; Iliffe et al., 2014; Iliffe et al., 2010; Stevens et al., 2013)	13a, 13b
Gitlin, 2006	(Gitlin et al., 2006a; Gitlin et al., 2006b; Gitlin et al., 2008)	14
Hafström, 2016	(Hafström et al., 2016)	15
Halvarsson, 2013	(Halvarsson et al., 2013; Halvarsson et al., 2011; Roaldsen et al., 2014)	16
Hamel, 2005	(Hamel & Lajoie, 2005)	17
Henwood, 2008	(Henwood et al., 2008)	18a, 18b
Hinman, 2002	(Hinman, 2002)	19a, 19b
Hosseini, 2018	(Hosseini et al., 2018)	20
Johnson, 2018	(Johnson et al., 2003; Johnson et al., 2018)	21a, 21b, 21c
Kim, 2020	(Kim & Yoo, 2020)	22
Lacroix, 2016	(Gschwind et al., 2013; Lacroix et al., 2016)	23a, 23b

First author, year	Citation	Study number (Table 1 main document)
Lai, 2013	(Lai et al., 2013)	24
Lee, 2007	(Lee et al., 2007)	25
Levy, 2016	(Levy et al., 2016)	26
Lü, 2016	(Lu et al., 2016)	27
Ma, 2019	(Ma et al., 2019)	28
Markle-Reid, 2010	(Markle-Reid et al., 2010; Markle-Reid et al., 2007)	29
McCormack, 2004	(McCormack et al., 2004)	30a, 30b
Menant, 2018	(Menant et al., 2017; Menant et al., 2018)	31
Metzelthin, 2013	(Metzelthin et al., 2013; Metzelthin et al., 2010)	32
Mortazavi, 2018	(Mortazavi et al., 2018)	33
Nguyen, 2012	(Nguyen & Kruse, 2012)	34
Nicholson, 2014	(Nicholson et al., 2014)	35
Nick, 2016	(Nick et al., 2013; Nick et al., 2016)	36a, 36b
Parry, 2016	(Parry et al., 2016; Parry et al., 2014)	37
Pighills, 2011	(Pighills et al., 2011)	38a, 38b
Pirauá, 2019	(Pirauá et al., 2019)	39a, 39b
Rendon, 2012	(Rendon et al., 2012)	40
Richeson, 2006	(Richeson et al., 2006)	41
Robertson, 2001	(Robertson et al., 2001)	42
Roller, 2018	(Roller et al., 2018)	43
Schoene, 2013	(Schoene et al., 2013)	44
Schwenk, 2016	(Schwenk et al., 2016)	45
Sheffield, 2013	(Sheffield et al., 2013)	46
Siegrist, 2016	(Blank et al., 2011; Freiberger et al., 2013; Siegrist et al., 2016)	47
Snooks, 2017	(Snooks et al., 2017)	48
Stanmore, 2019	(Stanmore et al., 2019)	49
Suttanon, 2018	(Suttanon et al., 2018)	50
Szturm, 2011	(Szturm et al., 2011)	51
Thiamwong, 2014	(Thiamwong & Suwanno, 2014)	52
Tousignant, 2012	(Tousignant et al., 2012)	53
van Haastregt, 2000	(van Haastregt et al., 2000)	54
Vrantsidis, 2009	(Vrantsidis et al., 2009)	55
Wallsten, 2006	(Wallsten et al., 2006)	56

First author, year	Citation	Study number (Table 1 main document)
Whitehead, 2018	(Whitehead et al., 2018; Whitehead et al., 2016)	57
Whyatt, 2015	(Whyatt et al., 2015)	58
Wollesen, 2017	(Wollesen et al., 2017a)	59a, 59b
Wollesen, 2017	(Wollesen et al., 2017b)	60a, 60b
Yamada, 2012	(Yamada et al., 2012)	61
Yoo, 2010	(Yoo et al., 2010)	62
Zhang, 2006	(Zhang et al., 2006)	63
Zhao, 2016	(Yanan & Pak-Kwong, 2015; Zhao et al., 2016)	64a, 64b
Zidén, 2014	(Dahlin-Ivanoff et al., 2010; Ziden et al., 2014)	65a, 65b
Zijlstra, 2009	(van Haastregt et al., 2013; Zijlstra et al., 2012; Zijlstra et al., 2005; Zijlstra et al., 2006; Zijlstra et al., 2009; Zijlstra et al., 2011)	66

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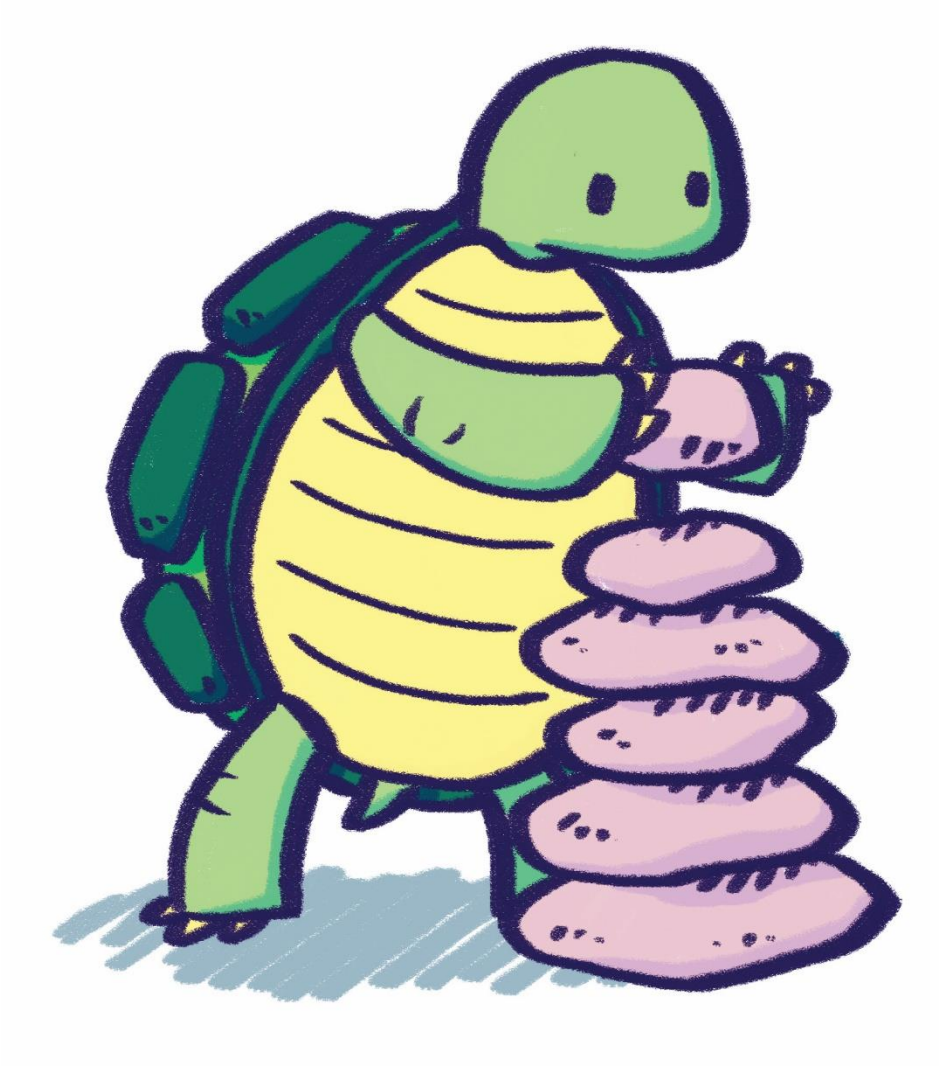

Chapter 4: Participant characteristics as moderators of the effects of cognitive behavioral interventions for concerns about falling: Secondary analyses of two randomized controlled trials

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Abstract

Background and Objectives: Effects of interventions may vary among participants and participant characteristics may be important to consider for intervention targeting and optimization. Our objective was to explore whether participant characteristics were moderators of the effects of two cognitive behavioral interventions for concerns about falling (CaF).

Research Design and Methods: Secondary data analyses of two RCTs, concerning the A Matter of Balance - Netherlands (n= 540) and A Matter of Balance - Home (n=389) interventions, were performed. For both datasets, we used linear mixed models to assess whether a participant characteristic moderated the effect of the intervention on CaF. Analyses included simple and elaborate models including multiple moderators at once. Nineteen potential demographic, health and socio-cognitive moderators were assessed.

Results: Most participant characteristics did not moderate the intervention effects. Moderating effects were found for living situation, fall history, symptoms of depression, perceived general health, ADL disability, cognitive status and consequences of falling - loss of independence subscale. Effects varied by intervention, time point and type of model.

Discussion and implications: Several demographic, health and socio-cognitive variables were found to moderate effects of AMB-NL and AMB-Home on CaF. These characteristics can be considered in the recruitment for these interventions and may guide modifications to the interventions.

Keywords: cognitive behavioral intervention, concerns about falling, effect modification, falls, fear of falling, intervention optimization, moderator

Introduction

Among older people, concerns about falling (CaF) - also called fear of falling - is common. Prevalences typically range between 21% and 85% (Scheffer et al., 2008). CaF is associated with poor physical functioning, activity avoidance, low social participation and lower quality of life. It may also present a problem for independence (Cumming et al., 2000; Howland et al., 1998; Meulen et al., 2014; Scheffer et al., 2008; Schoene et al., 2019). Interventions based on cognitive behavioral principles, such as challenging maladaptive thoughts, problem solving or graded exposure can reduce CaF. A recent meta-analysis of 15 studies evaluating cognitive behavioral interventions (Chua et al., 2019) showed short and long term effects, but small or moderate reductions in CaF. These promising interventions thus leave room for improvement.

Characteristics of participants are important factors to consider for intervention optimization as some people benefit more from interventions than others. For example, a study evaluating an exercise program showed a larger reduction in participants' fear of falling when they received less social support at baseline (Fukukawa et al., 2008). A potential explanation is that an exercise program may be particularly suitable for those that impose self-induced exercise restrictions due to lack of social support. Another example is a study by Tennstedt and colleagues, which concerned a cognitive behavioral group intervention involving restructuring misconceptions, goal setting, environmental changes and physical activity (Tennstedt et al., 2001). Compliers to the intervention who had higher baseline fear of falling scores, higher levels of physical and social functioning, and higher perceived control over falling benefited more from the intervention. In other words, the intervention was most beneficial for those with greater room for improvement, whose participation was not hindered by dysfunction and who believed they could do something about falling. Other than considering participant characteristics in recruitment, interventions can be modified to accommodate the groups that benefit less.

Currently, little is known about participant characteristics that moderate the effects of cognitive behavioral interventions on CaF in older community-dwelling people. The study by Tennstedt and colleagues is one of the few studies on this subject (Tennstedt et al., 2001). Yet, in addition to baseline CaF, physical

and social functioning, and perceived control over falling, other characteristics are potentially of interest. First, decreased cognitive functioning, hearing and visual problems, lack of mastery, and lack of social support occur more often in old age (Ellis, 1999; Evans, 2007) and could be relevant. Second, following the theory of planned behavior, several socio-cognitive variables, such as attitudes towards behaviors and perceived norms may influence the intention to engage in the intervention (Ajzen, 1991). Third, considering other populations and outcomes such as depression and anxiety, research shows that sex, age, educational level, living status, and comorbidity may influence outcomes of cognitive behavioral interventions (Beltman et al., 2010; Button et al., 2015; Gitlin et al., 2008; Hoifodt et al., 2015; Keeley et al., 2008; Knopp et al., 2013; Maher et al., 2010; Porter & Chambless, 2015; Raffin et al., 2009; Springer et al., 2018; Vestjens et al., 2015; Wetherell et al., 2005). Lastly, variables strongly associated with CaF may also be potential moderators, such as fall history and perceived general health (Denkinger et al., 2015).

The objective of this study was to explore whether participant characteristics are moderators of the effects of cognitive behavioral interventions on CaF in community-dwelling older people.

Materials and methods

This study concerns a secondary data-analysis of two randomized controlled trials (RCTs) of cognitive behavioral interventions in community-dwelling older adults. This study was pre-registered at Open Science Framework (OSF; DOI: 10.17605/OSF.IO/VXY6U) to increase transparency and reduce publication and reporting bias. Our main focus was the group intervention AMB-NL [Trial ID: ISRCTN43792817], but we also analyzed the data of the more recent AMB-Home intervention [Trial ID: NCT01358032]. A short description of the participants, procedures, interventions and outcome measures of both trials is given below. More information can be found elsewhere (Dorresteijn et al., 2011; Zijlstra et al., 2005).

Participants and procedures

In both RCTs, random samples of potential participants were obtained via municipality registers. In AMB-NL, community-dwelling older adults (≥70 years) were eligible to participate if they had some CaF and activity avoidance and lived

in the south of the Netherlands. Exclusion criteria were being confined to bed, being wheelchair dependent, participating in other intervention studies or waiting for nursing home admission. Criteria for AMB-Home were similar, but participants also had to perceive their health as fair or poor. Furthermore, they could not have substantial cognitive impairment or substantial hearing or visual impairment. In both trials, participants were assigned to an intervention group or usual care control group. Randomization was performed by an independent researcher (AMB-NL) or an external agency (AMB-Home). Participants and facilitators were not blinded to group assignment.

In AMB-NL, 280 people were allocated to the intervention group and 260 to the control group, 169 (60.4 %) and 209 (80.4%) completed the trial, respectively. In AMB-Home, 194 people were allocated to the intervention group and 195 people to the control group, of which 133 (68.6%) and 162 (83.1%) completed the trial, respectively. Baseline characteristics are shown in Appendix A. The samples were predominantly female and on average 78 years. The majority of participants lived alone. Comparing the samples in both studies, AMB-NL had relatively more people with impaired hearing or vision. AMB-Home had no people who rated their health as good and had more people with a chronic condition. These differences reflect the inclusion criteria.

Interventions

A Matter of Balance (AMB) was developed in the United States of America (Tennstedt et al., 1998), as a group intervention to reduce CaF and associated activity restriction. AMB has been adapted to the Dutch setting in A Matter of Balance – Netherlands (AMB-NL) (Zijlstra et al., 2006). AMB-NL is an 8-week intervention with weekly 2-hour group sessions (Zijlstra et al., 2005). The main topics include: an introduction to CaF and the program, thoughts and their influence on CaF, physical exercise, assertiveness, managing concerns through physical exercise and cognitive restructuring, fall risk behaviors, fall hazards in the home and community, and practicing safe behavior. Four main strategies are used throughout the intervention: restructuring misconceptions, goal setting, changing the home environment, and physical exercise. During the intervention, participants reflect on their own situation and discuss their own perspectives, but the group format also allows for feedback, social support and

comparison. Furthermore, there is attention for the implementation of strategies into daily life with personal action plans. AMB-NL includes a booster session six months after the last session.

AMB-Home is the home-based version of AMB-NL (Dorresteijn et al., 2011). It was developed to accommodate those people with health problems, a preference for an individual approach and/or a preference for an intervention at home (Dorresteijn et al., 2012). AMB-Home consists of seven sessions, of which the first four take place weekly and the last three sessions every two weeks. The sessions consist of three home visits and four telephone contacts (Dorresteijn et al., 2013). The topics and strategies of the intervention are similar to those of AMB-NL, but the physical exercises were replaced by an activity under the supervision of a nurse (exposure) and motivational interviewing was incorporated. Although social support and comparison is less pronounced than in the group intervention, participants in AMB-Home could invite a significant other to be present at the home visits for support and motivation between sessions (Dorresteijn et al., 2011).

Participants in the control groups received care as usual and, given the lack of treatments for CaF, it is likely these participants received no intervention (Dorresteijn et al., 2016; Zijlstra et al., 2009).

Measurements

Data was collected with self-report questionnaires and telephone interviews. Outcome assessors were trained and blinded to group assignment. In both trials, measurements were performed during screening, at baseline and directly after the intervention (T1). In the AMB-NL trial, there was a follow-up measurement at 6 (T2) and 12 months after the intervention (T3). In the AMB-Home trial, follow-up measurements were performed 7 months after the intervention (T2).

Outcome Measures

More details and a complete overview of all outcome measures are reported elsewhere (Dorresteijn et al., 2011; Zijlstra et al., 2005). Most outcome measures of the trials were identical; only not identical outcome measures are described separately below. The most favorable scores are underlined.

Dependent variable

CaF were measured by asking participants how concerned they are while carrying out activities of daily living (1= not at all concerned, 4 = very concerned). An adapted version of the 10-item Falls Efficacy Scale (FES) questionnaire, with four additional outdoor activity items, was used in AMB-NL (Zijlstra et al., 2005). In AMB-Home, CaF were measured with the 16-item Falls Efficacy Scale-International (FES-I; (Yardley et al., 2005)). A sum score was calculated for both questionnaires, resulting in a range of 14 to 56 for the adapted FES and a range of 16 to 64 for the FES-I.

Moderators

Demographics. The demographic variables were assessed by questionnaire during eligibility screening: age, sex (male/female), living situation (categorized as living alone/not living alone) and educational level (categorized as low/middle/high).

Health status. One item of the MOS Short-Form General Health Survey was used to assess perceived general health (categorized as good/fair/poor) (Stewart et al., 1988). Fall history in the past six months was assessed with one item (categorized as never/once/more than once). Disabilities in activities of daily living (ADL) were measured with the ADL subscale of the Groningen Activity Restriction Scale (GARS) (11 items, sum score 11-44) (Kempen et al., 2012). Chronic medical conditions were assessed with a 5-item questionnaire (categorized as at least one chronic condition/no chronic conditions) (CBS, 1989). Cognitive status was assessed with the 25-item Telephone Interview for Cognitive Status (TICS) in AMB-NL (sum score 0-41) (Brandt et al., 1988). Impaired vison was assessed with a 2-item questionnaire in AMB-NL and a 1-item questionnaire in AMB-Home (categorized as impaired/not impaired) (Van Sonsbeek, 1988). Impaired hearing was assessed similarly. Symptoms of depression and feelings of anxiety were measured with the two subscales of the Hospital Anxiety and Depression scale (each subscale contains 7 items, sum score 0-21) (Spinhoven et al., 1997).

Socio-cognitive. Mastery was assessed with the 7-item personal mastery scale (sum score 7-35) (Pearlin & Schooler, 1978). Social support was measured with the 12-item Social Support List of Interactions (SSL12-I) (sum score 12-48)

(Kempen & Van Eijk, 1995). Perceived control over falling was assessed with the 4-item Perceived Control over Falling (PCOF) scale (sum score 4-20) (Lawrence et al., 1998). Perceived consequences of falling were measured with the Consequences of Falling (CoF) scale, including the loss of functional independence and damage to identity subscales (each subscale contains 6 items, sum score 6-24) (Yardley & Smith, 2002).

Analysis

We used linear mixed models with restricted maximum likelihood (REML) estimation and an unstructured covariance structure for the repeated measures to assess whether a variable moderated the effect of the intervention on CaF. The syntaxes are available online at: https://osf.io/enzb6/?view_only=d7285e8930f4401e915a68f19638b751.

In the datasets, missing values were handled according to the administration rules of each measure (e.g. mean imputation was performed at the level of the scale when the number of missing items did not exceed the maximum number of missing items following the administration rules). If no guidelines were available, a maximum of 25% missing values was used for AMB-Home. For AMB-NL, a maximum of 15% missing values was used, except for the adapted FES, for which 25% of missing values was allowed. For both datasets, a likelihood-based approach, which assumes missingness at random, was used for remaining missing values in the outcome variables. A significance level of 0.05 was used to determine whether moderation was significant. No multiple testing correction was performed; we considered these analyses to be exploratory. Analyses were performed with IBM SPSS Statistics for Windows version 25 (Armonk, NY, USA; IBM Corp.). The fixed parts of the single moderator and elaborate models are described below.

Single moderator models

In the single moderator models, one moderator was entered at a time. The single moderator models consisted of the moderator at baseline, the group assignment variable and the categorical 'time' variable (using dummy variables; AMB-NL: 3 measurements, AMB-Home: 2 measurements). Additionally, analyses were corrected for baseline CaF and community. The following interactions were included as well: group x time, moderator x time, group x

moderator and group x time x moderator. We analyzed the following potential moderators measured at baseline: CaF, age, sex, living situation, educational level, ADL disability, chronic medical conditions, cognitive status (only for AMB-NL), visual impairment, hearing impairment, symptoms of depression, feelings of anxiety, mastery, social support, perceived control over falling and perceived consequences of falling (both subscales). At the time of our OSF pre-registration, fall history and perceived general health were not included as moderators. There is little evidence on these two variables as moderators of cognitive behavioral interventions, but we added them to the analyses due to their association with CaF.

Elaborate model

Like the single moderator models, the elaborate model included moderators at baseline, group, time, CaF at baseline, community, and 3- and 2-way interactions between group, time and moderator. However, the elaborate model included multiple moderators and interactions with moderators at once. We included moderators that showed promising results in the single moderator models, which was defined as a p-value ≤0.10 for the 2-way interaction group x moderator or the 3-way interaction group x moderator x time. The elaborate model also included the additional variables age, gender, fall history, perceived general health, educational level and living situation. See Appendix B for a list of all included variables.

Sensitivity analyses

Intention-to-treat analyses were performed. However, some variables may sort their effects through intention, motivation and compliance. Therefore, both in the single moderator models and the elaborate model we performed separate analyses in the group that attended 5 or more sessions ("on-treatment"/per-protocol analyses). Attending five sessions of the program has previously been considered as compliant (Dorresteijn et al., 2016).

Results

AMB-NL

Most variables were not significant moderators of the effects of AMB-NL on CaF. Symptoms of depression, cognitive status, ADL disability, consequences of falling (loss of independence subscale), and perceived health showed significant moderating effects varying by time point and type of analysis. In general, the single moderator models showed more significant moderators than the elaborate model. Additionally, the on-treatment analyses showed more moderators than the intention-to-treat analyses. Table 1 presents an overview of significant moderators. More details are described below.

Single moderator models, intention-to-treat outcomes

Symptoms of depression was a significant moderator at T1 in the single moderator model. The intervention acted as a buffer. This implies that CaF was similar in the intervention and control group for lower levels of depression (Figure 1). As symptoms of depression increased, so did CaF, but this was more pronounced in controls. This buffering effect of the intervention was also visible at T2, but it was not significant. Furthermore, the intervention and control group had similar levels of CaF for high levels of cognitive status at T2 (Figure 2). However, as cognitive status decreased, controls showed a higher level of CaF than those in the intervention group. Results were similar for T3, but the moderating effect was not significant.

Single moderators, on-treatment outcomes

Compared to the intention-to-treat analysis, moderating effects of symptoms of depression and cognitive status were similar in the on-treatment analyses, but effects were significant at more time points (Appendix C Figure 1a). Effects were also slightly more pronounced for symptoms of depression; as symptoms of depression increased, the intervention group showed a decrease in CaF. Furthermore, the analyses showed buffering effects of the intervention for increasing levels of ADL disability and perceived consequences of falling (loss of independence subscale) at T1 (Appendix C Figure 1b). The effect of the intervention also differed between categories of perceived general health at T1.

Table 1. Overview of significant moderators in A Matter of Balance - Netherlands and A Matter of Balance - Home.

A Matter of Balance – Netherlands (AMB-NL)						
	Single moderator models			**Elaborate model**		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**
Intention-to-treat	•Symptoms of depression	•Cognitive status				
On-treatment	•Symptoms of depression •ADL disability •Consequences of falling[a] •Perceived general health	•Cognitive status •Symptoms of depression	•Cognitive status		•Symptoms of depression	
A Matter of Balance – Home (AMB-Home)						
	Single moderator models			**Elaborate model**		
	T1	**T2**		**T1**	**T2**	
Intention-to-treat	•Perceived general health	•Fall history				
On-treatment	•Perceived general health •Living situation	•Fall history		•Living situation		

[a]Loss of independence subscale

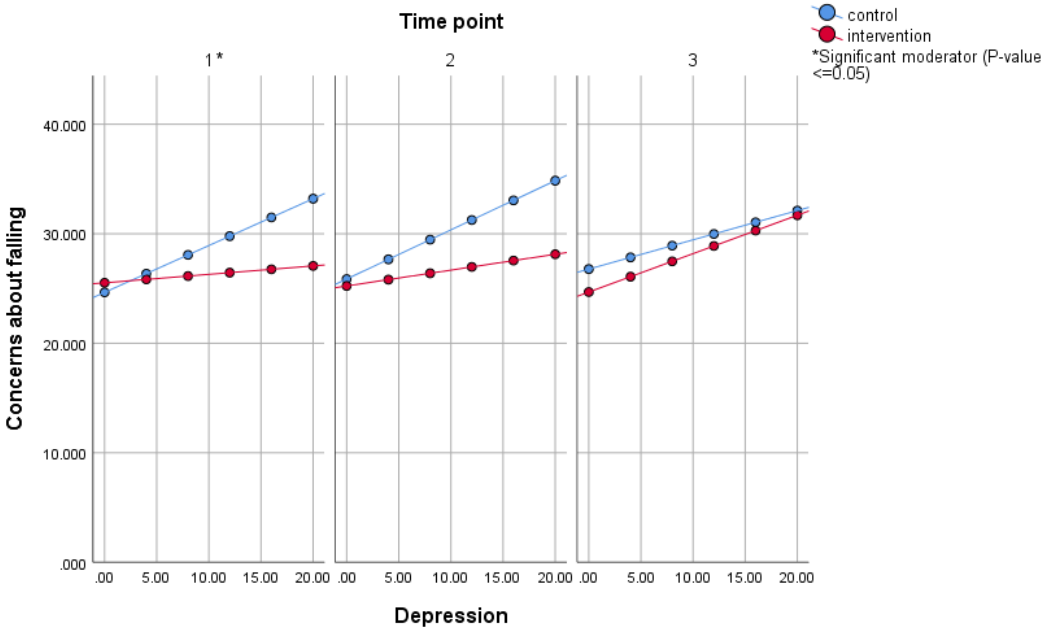

*Figure 1. Estimated mean concerns about falling for different values of symptoms of depression in the single moderator model, on-treatment analysis of A Matter of Balance-Netherlands. Model included group, time, community, baseline concerns, depression, group*time, depression*time, group*depression and group*time*depression. Sum scores range from 14 to 56 for concerns about falling and 0 to 21 for symptoms of depression (the underlined score is the most favorable score).*

There was a significant intervention effect for those in fair health, i.e. the adjusted mean CaF was significantly lower in the intervention group than in the control group (Appendix C Table 1, mean difference (95%CI): -3.68 (-5.46; -1.91)). Such an effect was not found for those in good health.

Elaborate model, intention-to-treat outcomes

There were no significant moderating effects in the intention-to-treat analyses of the elaborate model.

Elaborate model, on-treatment outcomes

Depression was a significant moderator in the on-treatment analysis of the elaborate model, at T2 only (Appendix C Figure 2).

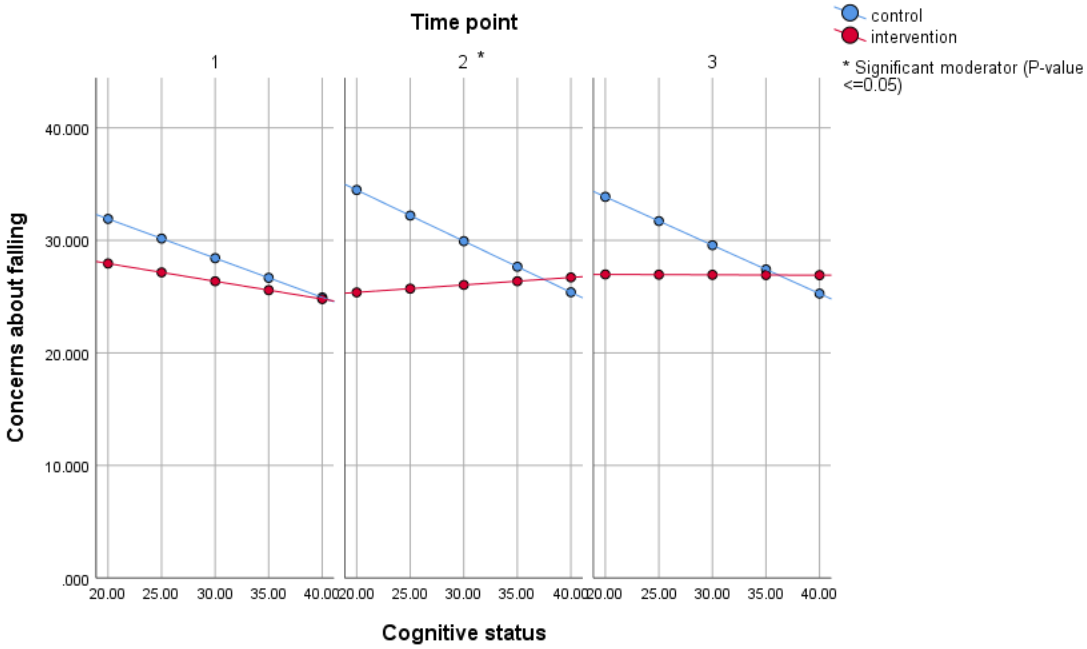

*Figure 2. Estimated mean concerns about falling for different values of cognitive status in the single moderator model, on-treatment analysis of A Matter of Balance-Netherlands. Model included group, time, community, baseline concerns, cognition, group*time, cognition*time, group*cognition and group*time*cognition. Sum scores range from 14 to 56 for concerns about falling and 0 to 41 for cognitive status (the underlined score is the most favorable score).*

AMB-Home

Similar to AMB-NL, most variables were not significant moderators of the effects of AMB-Home on CaF (Table 1). Also for AMB-Home, there were more significant moderators in the single moderator models and in the on-treatment analyses. Perceived general health, fall history and living situation showed significant moderating effects varying by time point and type of analysis.

Single moderators, intention-to-treat outcomes

At T1, a significant intervention effect is found among those in fair health (Table 2, mean difference (95%CI): -4.24 (-5.90; -2.59)), but not for those in poor health. Additionally, a significant effect is shown in those who have never fallen or fallen more than once at T2 (Table 2, mean difference never category (95% CI): -2.86 (-5.67; -0.05); mean difference more than once category (95%CI): -6.75 (-9.78; -3.71)). In contrast, the analyses showed no significant effect in those

Table 2. Intervention effects of A Matter of Balance - Home in categories of significant moderators. Results are from the intention-to-treat analysis.

Moderator	Time point[a]	Categories	Adjusted mean difference (95%CI)[b]	Adjusted mean difference (95%CI)[c]
Perceived general health	1[d]	Fair	-4.24(-5.90; -2.59)*	-3.18(-6.08; -0.27)*
		Poor	1.02(-3.89; 5.92)	0.90(-4.38; 6.17)
	2	Fair	-4.52(-6.35; -2.68)*	-5.49(-8.83; -2.16)*
		Poor	-0.11(-5.52; 5.30)	-0.67(-6.48; 5.14)
Falls in the past 6 months	1	Never	-5.30(-7.82; -2.79)*	-3.42(-7.53; 0.70)
		Once	-2.08(-5.07; 0.92)	-0.01(-4.11; 4.08)
		More than once	-2.85(-5.58; -0.12)*	0.01(-3.97; 3.99)
	2[d]	Never	-2.86(-5.67; -0.05)*	-2.70(-7.29; 1.89)
		Once	-2.15(-5.52; 1.23)	-1.38(-5.98; 3.23)
		More than once	-6.75(-9.78; -3.71)*	-5.17(-9.55; -0.78)*

[a]Time point 1= directly after the intervention, 2= 7 months after the intervention.
[b] Mean difference = Intervention – control. Single moderator model, adjustments for group, time, community, baseline concerns, moderator, group*time, moderator*time, group*moderator and group*time*moderator
[c] Mean difference = Intervention – control. Elaborate model, for adjustments please see the main text of the article.
[d]There is a significant difference (P-value ≤0.05) in intervention effects between categories of the moderator in single moderator model.
* There is a significant adjusted mean difference between intervention and control group.

who have fallen once. Similar findings are shown for T1, but without being significant.

Single moderators, on-treatment outcomes

Perceived health and fall history were still significant moderators in the on-treatment analyses of the single moderator models (Appendix D Table 1). Additionally, the effects in categories of living situation differed significantly at T1 (mean difference alone category (95% CI): -2.33 (-4.50; -0.15); mean difference not alone category (95%CI): -5.80 (-8.44; -3.16)).

Elaborate model, intention-to-treat outcomes

None of the variables significantly moderated effects in the intention-to-treat analysis of the elaborate model (Table 1).

Elaborate model, on-treatment outcomes

The effect of the intervention differed between categories of living situation at T1 (Appendix D Table 1, mean difference alone category (95% CI): 0.84 (-2.97; 4.65); mean difference not alone category (95%CI): -3.92 (-7.92; 0.09)).

Discussion

In the current study, we explored moderators of the effects of AMB-NL and AMB-Home, two cognitive behavioral interventions for managing CaF. Many variables were not significant moderators and none of the moderators in the elaborate models were significant on the long term. However, several demographic, health and socio-cognitive variables showed significant moderating effects depending on the intervention, time point and type of analysis (intention-to-treat or on-treatment).

Demographic

In several of our analyses, the effect of the AMB-Home intervention was larger for those living with someone else. Qualitative research on cognitive behavioral therapy (CBT) for depression has demonstrated that cohabitating can be a source of motivation, which can impact compliance (Wilhelmsen et al., 2013). However, living situation was only a moderator in the on-treatment analyses suggesting that the effect is not due to compliance. Participants in AMB-Home could invite a significant other to be present at the home visits. Having another person nearby may have helped participants to engage better with the intervention content; this could be an alternative explanation. Something similar was found in a qualitative study on CBT for insomnia (Dyrberg et al., 2021), in which family members helped to implement instructions from therapists. Fall history was also a significant demographic moderator. People who fall more often may not perform activities in a safe way (Butler et al., 2014; Zecevic et al., 2009). AMB specifically gives attention to safe behavior and thus these people may benefit from the intervention. There were slightly more fallers in AMB-Home than in AMB-NL, which may explain why this was only found for AMB-Home.

Health status

Of the evaluated health variables, depression, perceived health, ADL disability and cognitive status were moderators. In AMB-NL, the intervention acted as a buffer for depression, i.e. CaF barely increased with increasing levels of depression. When we only consider compliers (the on-treatment analysis), the intervention was even *more effective* for those with more severe depressive symptoms at baseline. This could imply that the skills taught in AMB-NL - such as cognitive restructuring, problem solving and exposure – were transferred to other situations in the older person's life, resulting in an enhanced intervention effect.

Perceived health was a moderator in both interventions. For AMB-NL, CaF was effectively reduced in those in fair health, but not in those in good health. People in fair health may be less confident (Lach, 2005) and may have more misconceptions about activities they can safely perform. Disparities between perceived and physiological fall risk can occur in older people (Delbaere et al., 2010). The cognitive behavioral intervention addresses restructuring misconceptions and safely performing activities, and people in fair health could benefit more. Additionally, AMB-NL is a group intervention and social comparison may motivate participants to try activities they otherwise would not try to perform. Previous research has demonstrated that social modelling may motivate older adults to perform physical activity (Booth et al., 2000; Warner et al., 2011). A similar social modelling mechanism could explain the moderating effect of ADL-disability that we found for AMB-NL. In contrast, poor health may limit possibilities to effectively engage in the intervention; AMB-Home was effective in those in fair health, but not in those in poor health.

Lastly, for AMB-NL, varying levels of cognitive status did not affect CaF in the intervention group much. In contrast, in the control group, those with a poor cognitive status had higher levels of CaF. AMB-NL contains elements that can be cognitively stimulating. As cognition and CaF appear associated (Noh et al., 2019; Uemura et al., 2015), improvements in cognition may lead to improvements in CaF. In the current study we did not take into account changes in cognitive status over time; if those with poor cognitive status improved due to the intervention, this may explain why CaF in the intervention group was not higher.

Socio-cognitive

Only one of our socio-cognitive variables was significant as a moderator. In the control group of the AMB-NL trial, CaF increased with increasing scores of the consequences of falling - loss of independence subscale. This was not the case in the intervention group. The intervention participants that scored high on the consequences of falling scale at baseline, may have adopted more realistic thoughts during the intervention if they learned that falls do not necessarily lead to negative outcomes and that they can reduce their risk of falling.

Strengths and limitations

The RCTs included relatively large samples and we explored many potential moderators from the demographic, health and socio-cognitive domains. Multiple models were used, with limited and elaborate adjustments. However, this study was also subject to several limitations. Because we used existing data, we were limited to the characteristics that have been measured in the AMB-NL and AMB-Home trials and no sample size calculations were performed. Additionally, in these exploratory analyses, we used a significance limit of 0.05 to test interaction effects and did not use a multiple testing correction. Therefore, there is an increased risk of type 1 error.

Implications

We anticipated to find moderators that could help target treatment or that would provide clues for intervention optimization. We mainly found that AMB-NL and AMB-Home may help to diminish detrimental effects, i.e. act as buffers. For example, more ADL disability, more symptoms of depression and low cognitive status at baseline were associated with more CaF in the control group, but not in the intervention group. Although recruiting people with these characteristics may be challenging, participation may be advantageous for them and it is important to make efforts to include them. Specific recruitment strategies could help, such as using multimodal forms of communication (not only written information), placing brochures and posters in waiting rooms of health care providers and collaborating with agencies for independent living to directly contact individuals (Banas et al., 2019). Other characteristics that moderated the relation between the intervention and CaF, such as sex, living situation and fall history, are not easily modifiable, but may be highlighted in the

manuals with a textbox. For example, for those with a fall history, it may prove beneficial to focus on safe behavior, or for those that live alone, more intervention specific support may be needed.

Further research

Studies often report average effects, but people over the age of 65 years are a highly heterogeneous group and effects may differ according to participant characteristics. In addition to the characteristics examined here, other potential moderators warrant exploring, such as participant's expectations on intervention benefits prior to the start of the intervention. For group interventions, the composition and characteristics of the group may be considered (Wilson et al., 2019). Secondary data-analysis can be a suitable method for future research into potential moderators. Lastly, AMB-NL and AMB-Home are similar in their content, but they yielded some different results. Reviews on CBT for obsessive compulsive disorder and social phobia also showed that predictors of effects can be different for similar interventions on the same outcomes (Eskildsen et al., 2010; Keeley et al., 2008). More research on different cognitive behavioral interventions is needed to determine whether moderators of effects on CaF are content specific.

Conclusion

In the current study, living situation, fall history, symptoms of depression, perceived general health, ADL disability, cognitive status, and consequences of falling - loss of independence were moderators of the effects of AMB-NL or AMB-Home. These participant characteristics are important to consider in the recruitment of participants and may guide further intervention optimization.

Disclosure statement

We have no conflict of interest to declare.

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data interpretation, writing of the manuscript, or the decision to submit the manuscript for publication.

Data Availability Statement

The syntaxes that support the findings of this study are openly available in Open Science Framework (https://osf.io/enzb6/?view_only=d7285e8930f4401e915a68f19638b751). Data is not publicly available due to the provided informed consent.

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Appendix A – Baseline characteristics

Table 1. Baseline characteristics of analyzed samples of the two randomized controlled trials evaluating A Matter of Balance - NL and A Matter of Balance - Home.

	AMB-NL				AMB-Home			
Baseline characteristic	**Intervention group (n=280)**		**Control group (n= 260)**		**Intervention group (n= 194)**		**Control group (n= 195)**	
Concerns about falling[a], mean (SD)	28.50	(9.55)	29.97	(10.16)	35.70	(10.37)	35.47	(9.40)
Demographic								
Age at baseline, mean (SD)	77.5	(4.6)	78.1	(5.0)	78.4	(5.4)	78.3	(5.3)
Female, n (%)	198	(70.7)	190	(73.1)	132	(68.0)	141	(72.3)
Living alone, n (%)	157	(56.1)	138	(53.1)	110	(56.7)	118	(60.5)
Educational level, n (%)								
Low	185	(66.1)	153	(58.8)	110	(56.7)	100	(51.3)
Middle	60	(21.4)	64	(24.6)	55	(28.4)	72	(36.9)
High	35	(12.5)	42	(16.2)	27	(13.9)	22	(11.3)
Health								
Perceived general health, n (%)								
Good	79	(28.2)	86	(33.1)	-		-	
Fair	187	(66.8)	161	(61.9)	166	(85.6)	176	(90.3)
Poor	14	(5.0)	13	(5.0)	28	(14.4)	19	(9.7)
Falls in the past 6 months, n (%)								
Never	123	(43.9)	117	(45.0)	64	(33.0)	81	(41.5)
Once	61	(21.8)	48	(18.5)	54	(27.8)	55	(28.2)
More than once	96	(34.3)	95	(36.5)	74	(38.1)	56	(28.7)

Baseline characteristic	AMB-NL				AMB-Home			
	Intervention group (n=280)		Control group (n= 260)		Intervention group (n= 194)		Control group (n= 195)	
ADL disability (range 11-44), mean (SD)	17.14	(4.44)	17.40	(4.53)	18.47	(4.85)	18.70	(4.94)
≥ 1 chronic medical condition, n (%)	110	(39.3)	113	(43.5)	178	(91.8)	186	(95.4)
Cognitive status (range 0-41), mean (SD)	31.69	(3.63)	32.22	(3.86)	-		-	
Impaired vision, n (%)	42	(15.0)	46	(17.7)	18	(9.3)	20	(10.3)
Impaired hearing, n (%)	52	(18.6)	51	(19.6)	8	(4.1)	6	(3.1)
Symptoms of depression (range 0-21), mean (SD)	7.17	(4.35)	6.70	(3.94)	6.24	(3.85)	5.96	(3.63)
Feelings of anxiety (range 0-21), mean (SD)	6.85	(3.97)	7.55	(4.66)	6.61	(4.53)	7.12	(4.30)
Socio-cognitive								
Mastery (range 7-35), mean (SD)	21.45	(4.59)	20.92	(4.65)	21.17	(4.80)	20.93	(4.66)
Social support (range 12-48), mean (SD)	28.70	(6.63)	30.42	(6.68)	29.63	(6.45)	29.09	(6.89)
PCOF (range 4-20), mean (SD)	13.48	(3.06)	13.09	(3.11)	13.06	(2.95)	13.19	(2.95)
Perceived consequences of falling - LFI (range 6-24), mean (SD)	14.62	(3.35)	14.90	(3.41)	15.57	(3.29)	15.60	(3.07)
Perceived consequences of falling - DI (range 6-24), mean (SD)	14.73	(2.95)	14.89	(2.95)	15.49	(3.14)	15.88	(2.84)

SD = standard deviation. ADL = activities of daily living. PCOF = perceived control over falling. LFI = loss of functional independence. DI = damage to identity. AMB-NL = A Matter of Balance – Netherlands (group intervention). AMB-Home = A Matter of Balance – Home (individual intervention).
Most favorable scores are underlined.
[a] For AMB-NL, concerns about falling were measured with the adapted Falls Efficacy Scale (sum score range 14 – 56). For AMB-Home, the Falls Efficacy Scale – International was used (sum score range 16-64).

Appendix B – List of variables corrected for in elaborate models

Table 1. List of the variables that were included in the elaborate model of the moderator analysis of the randomized controlled trial evaluating A Matter of Balance – NL

AMB-NL, intention to treat analysis	AMB-NL, on-treatment analysis
Group	Group
Time	Time
Community	Community
Baseline CaF	Baseline CaF
Age	Age
Sex	Sex
Fall history	Fall history
Perceived general health	Perceived general health
Educational level	Educational level
Living situation	Living situation
Hearing impairment	ADL disability
Feelings of anxiety	Symptoms of depression
Symptoms of depression	Cognitive status
Cognitive status	Perceived consequences – loss of functional independence
Perceived consequences – damage to identity	Perceived consequences – damage to identity
Group * time	Group * time
Sex * time	Sex * time
Hearing impairment * time	ADL disability * time
Feelings of anxiety * time	Symptoms of depression * time
Symptoms of depression * time	Cognitive status * time
Cognitive status * time	Perceived consequences – loss of functional independence * time

Perceived consequences – damage to identity * time	Perceived consequences – damage to identity * time
Group * sex	Perceived general health * time
Group * hearing impairment	Group * sex
Group * feelings of anxiety	Group * ADL disability
Group * symptoms of depression	Group * symptoms of depression
Group * cognitive status	Group * cognitive status
Group * perceived consequences – damage to identity	Group * perceived consequences – loss of functional independence
Group * time * sex	Group * perceived consequences – damage to identity
Group * time * hearing impairment	Group * perceived general health
Group * time * feelings of anxiety	Group * time * sex
Group * time * symptoms of depression	Group * time * ADL disability
Group * time * cognitive status	Group * time * symptoms of depression
Group * time * perceived consequences – damage to identity	Group * time * cognitive status
	Group * time * perceived consequences – loss of functional independence
	Group * time * perceived consequences – damage to identity
	Group * time * perceived general health

ADL = Activities of daily living. CaF = concerns about falling. AMB-NL = A Matter of Balance – Netherlands.

Table 2. List of the variables that were included in the elaborate model of the moderator analysis of the randomized controlled trial evaluating A Matter of Balance – Home.

AMB-Home, intention to treat analysis	AMB-Home, on-treatment analysis
Group	Group
Time	Time
Community	Community
Baseline CaF	Baseline CaF
Age	Age
Sex	Sex
Fall history	Fall history
Perceived general health	Perceived general health
Educational level	Educational level
Living situation	Living situation
Visual impairment	Visual impairment
Feelings of anxiety	Social support
Group * time	Perceived consequences of falling
Visual impairment * time	Group * time
Feelings of anxiety * time	Fall history * time
Fall history * time	Perceived general health * time
Perceived general health * time	Living situation * time
Group * visual impairment	Visual impairment * time
Group * feelings of anxiety	Social support * time
Group * fall history	Perceived consequences of falling * time
Group * perceived general health	Group * fall history
Group * time * visual impairment	Group * perceived general health

Group * time * feelings of anxiety	Group * living situation
Group * time * fall history	Group * visual impairment
Group * time * perceived general health	Group * social support
	Group * perceived consequences of falling
	Group * time * fall history
	Group * time * perceived general health
	Group * time * living situation
	Group * time * visual impairment
	Group * time * social support
	Group * time * perceived consequences of falling

CaF = concerns about falling. AMB-Home = A Matter of Balance – Home.

Appendix C – AMB-NL on-treatment moderator analysis outcomes

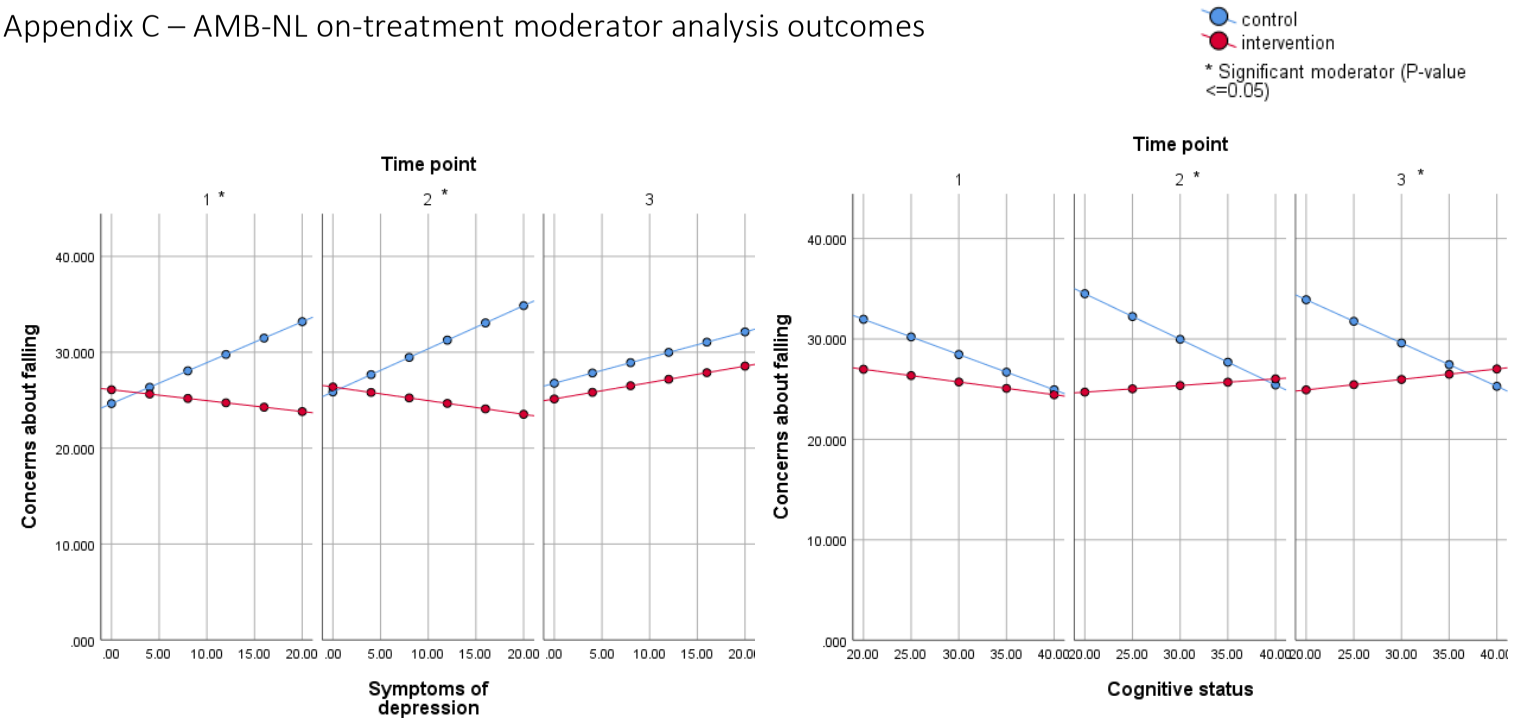


*Figure 1a. Estimated mean concerns about falling for different values of moderators in the single moderator models, on-treatment analyses of A Matter of Balance-Netherlands. Model included group, time, community, baseline concerns, moderator, group*time, moderator*time, group*moderator and group*time*moderator. Sum scores range from 14 to 56 for concerns about falling, 0 to 21 for symptoms of depression, 0 to 41 for cognitive status.*

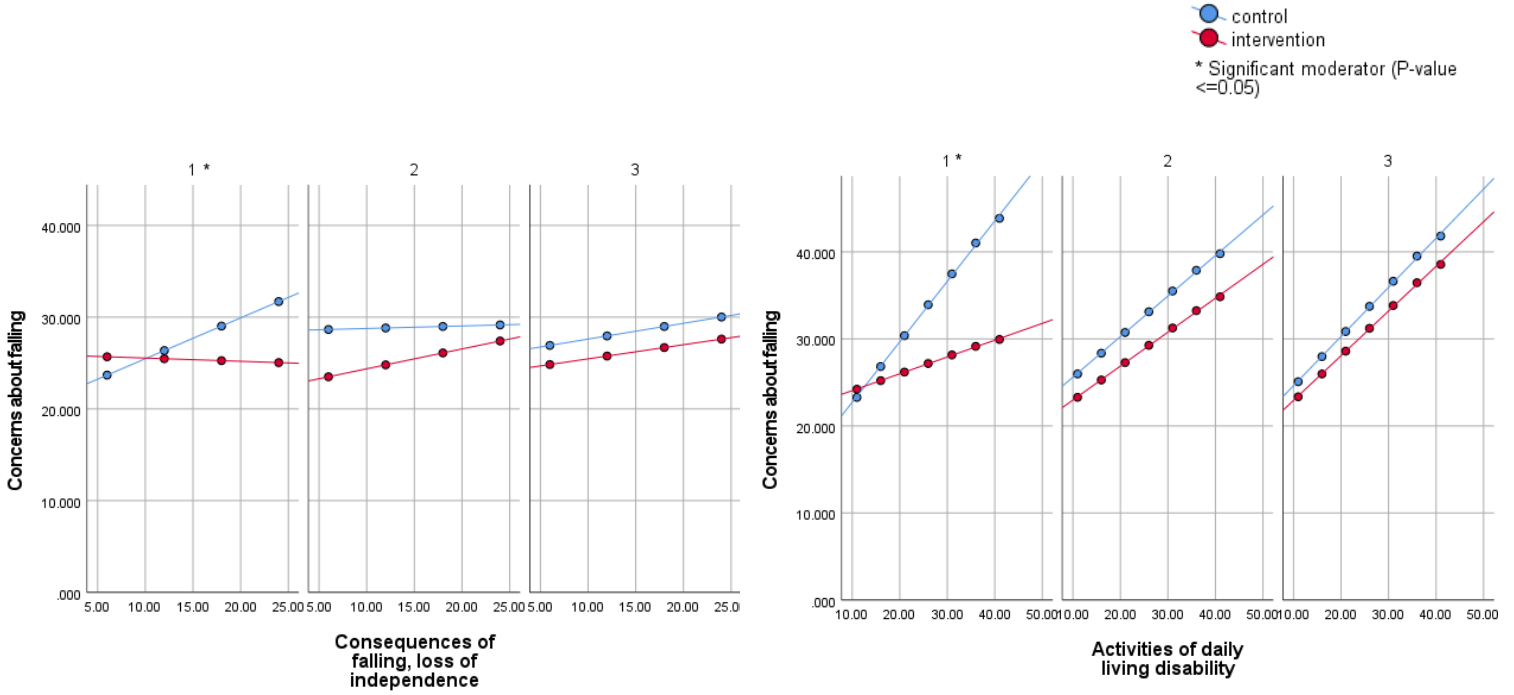


*Figure 1b. Estimated mean concerns about falling for different values of moderators in the single moderator models, on-treatment analyses of A Matter of Balance-Netherlands. Model included group, time, community, baseline concerns, moderator, group*time, moderator*time, group*moderator and group*time*moderator. Sum scores range from 14 to 56 for concerns about falling, 11 to 44 for activities of daily living disability, 6 to 24 for consequences of falling (the underlined score is the most favorable score).*

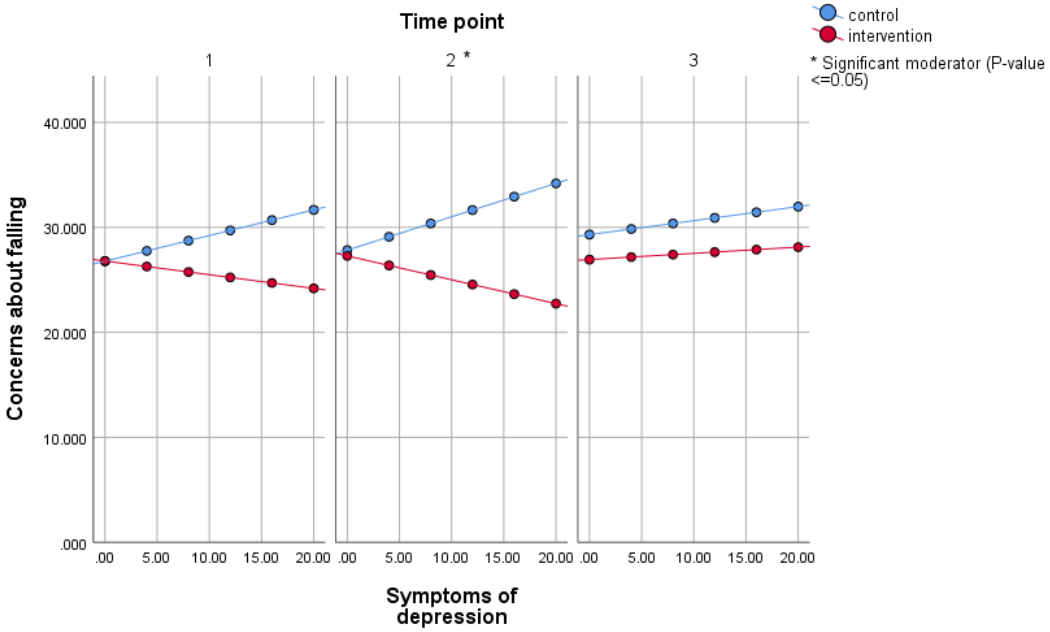


Figure 2. Estimated mean concerns about falling for different values of symptoms of depression in the elaborate model, on-treatment analyses of A Matter of Balance-Netherlands. For adjustments, please see the main text of the article. The Sum scores range from 14 to 56 for concerns about falling and 0 to 21 for symptoms of depression (the underlined score is the most favorable score).

Table 1. Intervention effects of A Matter of Balance – Netherlands in categories of perceived health in the on-treatment analyses.

Moderator	Time point [a]	Categories[b]	Single moderator model, Adjusted mean difference (95%CI)[c]		Elaborate model, Adjusted mean difference (95%CI)[d]	
Perceived general health	1[e]	Good	1.44	(-1.04; 3.92)	0.15	(-2.49; 2.79)
		Fair	-3.68	(-5.46; -1.91)*	-3.38	(-5.21; -1.56)*
	2	Good	-1.78	(-4.94; 1.38)	-2.64	(-6.02; 0.74)
		Fair	-3.68	(-5.94; -1.42)*	-3.14	(-5.48; -0.79)*
	3	Good	-0.16	(-3.27; 2.96)	-0.83	(-4.21; 2.56)
		Fair	-2.93	(-5.12; -0.74)*	-2.56	(-4.88; -0.24)*

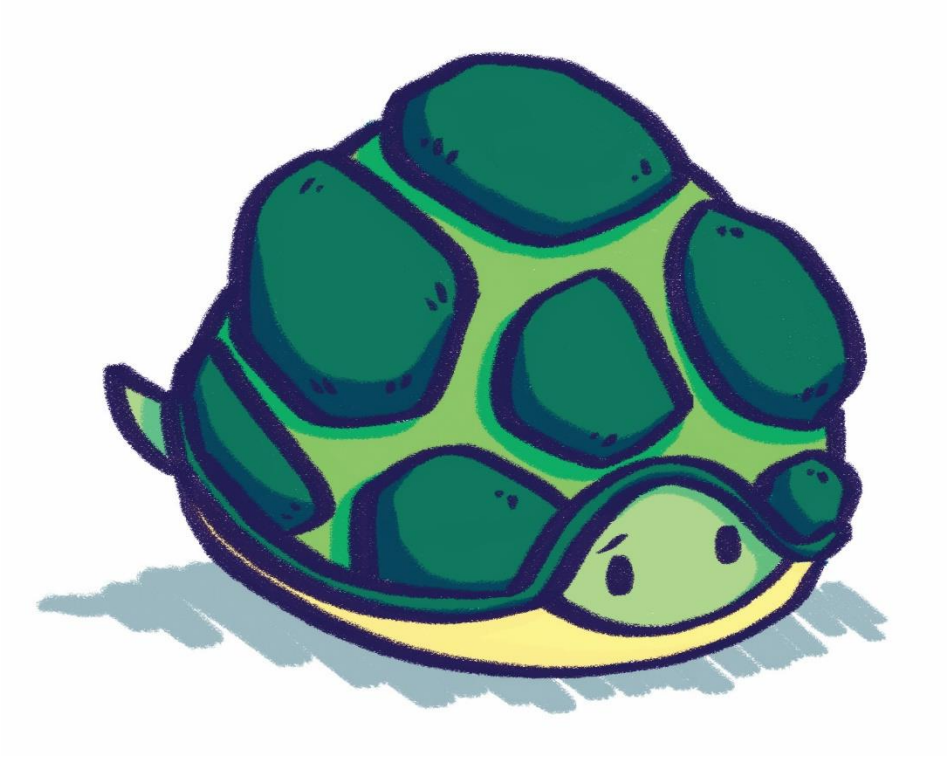
[a] Time point 1 = directly after the intervention, 2 = 6 months after the intervention, 3 = 12 months after the intervention.
[b] Number of people in poor health category was too low to estimate adjusted mean differences; this category is not shown.
[c] Mean difference = Intervention - control. Single moderator model, adjustments for group, time, community, baseline concerns, moderator, group*time, moderator*time, group*moderator and group*time*moderator.
[d] Mean difference = Intervention - control. Elaborate model, for adjustments please see the main text of the article.
[e] There is a significant difference (P-value ≤0.05) in intervention effects between categories of the moderator in the single moderator model.
* There is a significant adjusted mean difference between intervention and control group.

Appendix D - AMB-Home on-treatment moderator analysis outcomes

Table 1. Intervention effects of A Matter of Balance - Home in categories of significant moderators. Results are from the on-treatment analysis.

Moderator	Time point [a]	Categories	Single moderator model, Adjusted mean difference (95%CI)[b]		Elaborate model, Adjusted mean difference (95%CI)[c]	
Living situation	1[d, e]	Alone	-2.33	(-4.50; -0.15)*	0.84	(-2.97; 4.65)
		Not alone	-5.80	(-8.44; -3.16)*	-3.92	(-7.92; 0.09)
	2	Alone	-2.87	(-5.27; -0.48)*	-1.81	(-6.01; 2.40)
		Not alone	-5.29	(-8.23; -2.34)*	-5.30	(-9.80; -0.80)*
Perceived general health	1[d]	Fair	-4.34	(-6.13; -2.55)*	-3.63	(-6.81; -0.45)*
		Poor	1.08	(-3.83; 5.99)	0.56	(-4.78; 5.89)
	2	Fair	-4.42	(-6.40; -2.44)*	-5.89	(-9.51; -2.27)*
		Poor	-0.11	(-5.50; 5.29)	-1.22	(-7.09; 4.66)
Fall in the past 6 months	1	Never	-4.90	(-7.66; -2.13)*	-3.39	(-7.69; 0.90)
		Once	-1.61	(-4.73; 1.50)	-0.02	(-4.33; 4.29)
		More than once	-3.61	(-6.52; -0.69)*	-1.20	(-5.39; 2.99)
	2[d]	Never	-1.77	(-4.83; 1.29)	-2.59	(-7.39; 2.20)
		Once	-2.09	(-5.53; 1.38)	-1.90	(-6.73; 2.92)
		More than once	-7.27	(-10.50; -4.05)*	-6.17	(-10.79; -1.55)*

[a] Time point 1= directly after the intervention, 2= 7 months after the intervention.
[b] Mean difference = Intervention - control. Single moderator model, adjustments for group, time, community, baseline concerns, moderator, group*time, moderator*time, group*moderator and group*time*moderator.
[c] Mean difference = Intervention - control. Elaborate model, for adjustments please see the main text of the article.
[d] There is a significant difference (P-value ≤0.05) in intervention effects between categories of the moderator in single moderator model.
[e] There is a significant difference (P-value ≤0.05) in intervention effects between categories of the moderator in elaborate model.
* There is a significant adjusted mean difference between intervention and control group.



Part 2
Measuring activity avoidance due to fear of falling

Chapter 5: Assessing avoidance behavior due to concerns about falling: Psychometric properties of the FES-IAB in a sample of older adults of an online panel

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Abstract

Background and Objectives: The Falls Efficacy Scale-International (FES-I) and its shorter version (Short FES-I) are widely used measures of concerns about falling (CaF) and have consistently demonstrated good psychometric properties. The FES-I Avoidance Behavior (FES-IAB) and Short FES-IAB were developed to gain insight into activity avoidance due to CaF and add a question to each item of the FES-I and Short FES-I. The objective was to assess the psychometric properties of the FES-IAB and Short FES-IAB in community-dwelling older people.

Methods: A community-dwelling sample of the Dutch population (n=744) aged 60 and over completed the FES-IAB twice with one month in between (with a follow-up response rate of 92.2%).

Results: Confirmatory factor analysis confirmed the unidimensionality of the FES-IAB, with high factor loadings and very good fit. The scale correlated strongly with the FES-I, and moderately with ADL disability and 1-item questions of activity avoidance and CaF. The FES-IAB discriminated well between groups based on age, sex, fall history and mental health. Internal consistency and test-retest reliability were high (Cronbach's alpha: 0.92, intraclass correlation coefficient: 0.85). FES-IAB scores were positively skewed; 343 people (46.1%) had the lowest possible score of 16. The psychometric properties of the Short FES-IAB were comparable. No problems were identified with the feasibility of the FES-IAB and Short FES-IAB.

Discussion: Overall, the FES-IAB and Short FES-IAB demonstrated good psychometric properties in assessing activity avoidance due to CaF in community-dwelling older people. These instruments may help researchers and clinicians to investigate the behavioral consequences of CaF.

Keywords: activity avoidance, fear of falling, validity, reliability, questionnaire, avoidance behavior, concerns about falling, psychometric properties, older adults

Introduction

In fall prevention research, the Falls Efficacy Scale-International (FES-I) is often used to measure concerns about falling (CaF) in older people. The FES-I contains 16 items that describe a variety of activities, making it suitable for populations varying in terms of physical functioning (Yardley et al., 2005). It has been translated into many languages and has consistently demonstrated good internal consistency, test-retest reliability, face validity, convergent, divergent and discriminative validity, and unidimensionality (Prevention of Falls Network Europe, n.d.-b). A validated short version, the 7-item Short FES-I, is also available (Kempen et al., 2008). Hence, an internationally validated measure is available for CaF, but this is lacking for avoidance behavior due to CaF.

Avoidance behavior due to CaF, also called activity restriction, is common among community-dwelling older people and consists of self-imposed avoidance, restriction, or limitation of activities that one is still capable of performing (Zijlstra, 2007). It is associated with poor physical performance, limitations in activities of daily living (ADL), and disability (Belloni et al., 2020; Delbaere et al., 2004; Deshpande et al., 2008; Kempen et al., 2009; van der Meulen et al., 2014). Thus, it can limit aging in place (Cumming et al., 2000), while remaining independent is often the preference of older people and may help reduce the pressure that aging puts on healthcare systems (Marek et al., 2012; World Health Organisation, 2011). Therefore, a feasible measure for avoidance behavior with good psychometric properties is imperative.

Currently used avoidance measures, such as The Survey of Activities and Fear of Falling in the Elderly (SAFFE) (Lachman et al., 1998) or the Fear of Falling Avoidance Behavior Questionnaire (FFABQ) (Landers et al., 2011), have shown evidence of reliability and validity (Acaröz Candan et al., 2020; Delbaere et al., 2004; Hotchkiss et al., 2004; Huang, 2006; Jonasson et al., 2014; Lachman et al., 1998; Landers et al., 2011; Liu & Ng, 2019; Nilsson et al., 2010; Talley et al., 2008; Yardley & Smith, 2002). However, compared to the FES-I, they have not been as extensively validated and are less widely used (Prevention of Falls Network Europe, n.d.-b). Dorresteijn and colleagues developed the FES-I Avoidance Behavior (FES-IAB) (Dorresteijn et al., 2011). For each item in the FES-I, people indicate to what extent they avoid the activity due to their CaF. Rather than using one of the existing measures, which do not precisely match the FES-I's

items and types of activities, combining a questionnaire for avoidance behavior due to CaF with the FES-I is more practical since data gathering is more efficient and less burdensome for participants. Furthermore, because the FES-I is already applied in different cultures and settings, it facilitates international comparison. The FES-IAB has been used previously (Dorresteijn et al., 2016), but it has not been extensively validated yet. The current study aimed to assess the psychometric properties of the FES-IAB and shortened FES-IAB in community-dwelling older people.

Methods

Procedures and participants

In this paper, we use data from the LISS (Longitudinal Internet studies for the Social Sciences) panel administered by CentERdata (Tilburg University, The Netherlands). The LISS panel is based on a true probability sample of Dutch households drawn from the population register by Statistics Netherlands. Every year, participants complete an internet survey covering a variety of domains. This survey is the LISS panel core study (CentERdata, n.d. a; Scherpenzeel & Das, 2010). Furthermore, participants fill out questionnaires monthly. Households that would not be able to participate otherwise are provided with a computer and internet connection (CentERdata, n.d. a).

Participants in the current study were adults aged 60 or over. There were no criteria for exclusion. The FES-IAB was administered as part of a larger physical activity questionnaire. The first wave of this questionnaire (T1) was administered in March-May 2013. Men and women were sampled equally (50%-50%). Responders received the questionnaire again in a second wave (T2) during April-June 2013 (CentERdata, 2013).

The reporting of this study adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for observational studies (Von Elm et al., 2007). See the supplementary material at the journal website. Ethical approval was not required for this study. All participants provided informed consent (CentERdata, n.d. b).

Measures

Concerns about falling and activity avoidance

The FES-I was administered as part of the FES-IAB. The FES-I is a 16-item questionnaire on the level of CaF when carrying out activities. Answer options of the FES-I include 1=not at all concerned, 2=somewhat concerned, 3=fairly concerned, and 4= very concerned (theoretical range sum score: 16-64 (Yardley et al., 2005)). For the FES-IAB, people indicate to what extent they avoid an activity due to their concerns for each item of the FES-I. The answer options of the FES-IAB are 1=no, never, 2=yes, sometimes, 3=yes, regularly, and 4=yes, often. Questions about avoidance behavior are only asked when people indicate that they are at least somewhat concerned (i.e., answer options 2, 3, and 4 of the FES-I). If people are not concerned (i.e., answer option 1 of the FES-I), a score of 1 is assigned to the item. For the sum score of the FES-IAB, all scores on the individual items are added up, resulting in a theoretical range of 16-64. The Short FES-IAB contains a selection of seven items out of the FES-IAB; the seven items are based on the Short FES-I (theoretical range sum score: 7-28 (Kempen et al., 2008)). See Box 1 for more details.

Other measures

One item on CaF ("Are you concerned about falling?") and related activity avoidance ("Do you avoid certain activities due to concerns about falling?") was included; response options ranged from 1 (never) to 5 (very often). Disability in ADL was assessed with the Groningen Activity Restriction Scale (GARS), using the ADL subscale (theoretical range: 11-44 (Kempen et al., 2012)) and physical activity was assessed with the short International Physical Activity Questionnaire (IPAQ), in metabolic equivalents of task (MET)-minutes per week (IPAQ Research Committee, 2005). Moreover, the frequency of falls in the past six months was assessed ("How often have you fallen in the past six months?"); answer options 0=never, 1=once, 2=twice, and 3=three times or more. Age, sex, living situation (alone or not), educational level, perceived general health, and mental health - assessed with the Mental Health Inventory-5 (MHI, theoretical range: 0-100 (Stewart et al., 1988)) - were extracted from the core study. For further specifics, see the LISS panel codebooks (CentERdata, 2014, 2020, 2021).

Box 1. Introduction, items, response options and scoring instructions of the FES-IAB and Short FES-IAB.

Instructions:

For the FES-IAB, after each item of the FES-I (Yardley et al., 2005) or Short FES-I (Kempen et al., 2008) also add the item about activity avoidance if the respondent indicated at least some concerns about falling.

Introduction:

Now we would like to ask some questions about how concerned you are about the possibility of falling. Please reply thinking about how you usually do the activity. If you currently don't do the activity (for example if someone does your shopping for you), please answer to show whether you think you would be concerned about falling IF you did the activity. For each of the following activities, please tick the box which is closest to your own opinion to show how concerned you are that you might fall if you did this activity. If you have at least some concerns about falling, also indicate whether you avoid the activity due to your concerns about falling.

Items:

How concerned are you that you might fall if:

1. Cleaning the house (for example when sweeping, vacuum cleaning or dusting)
2. Getting dressed or undressed *
3. Preparing simple meals
4. Taking a bath or shower*
5. Going to the shop
6. Getting in or out of a chair*
7. Going up or down stairs*
8. Walking around in the neighborhood
9. Reaching for something above your head or on the ground*
10. Going to answer the telephone before it stops ringing
11. Walking on a slippery surface (for example wet or icy)
12. Visiting a friend or relative
13. Walking in a place with crowds
14. Walking on an uneven surface (for example on rocky ground or a poorly maintained pavement)
15. Walking up or down a slope*
16. Going out to a social event (for example religious service, family gathering or club meeting)*

For each item with at least some concerns about falling also ask: Do you avoid performing this activity due to concerns about falling?

*For the Short FES-I and Short FES-IAB, only use these items.

Answer options FES-I:
1 = not at all concerned, 2 = somewhat concerned, 3 = fairly concerned, 4 = very concerned

Answer options FES-IAB:
1 = no, never, 2 = yes, sometimes, 3 = yes, regularly, 4 = yes, often

Scoring instructions:

Scoring of the FES-IAB and Short FES-IAB is based on the scoring of the FES-I and Short FES-I.
(Prevention of Falls Network Europe, n.d.-a). For all items of the FES-I on which the respondent indicated no concerns about falling, always give a score of 1 (no, never) for the FES-IAB.

Scoring without missing items:
To calculate the FES-IAB or Short FES-IAB score when all items are completed, add the scores for each item together to give a total that ranges as follows:
FES-IAB: minimum 16 (no activity avoidance due to concerns about falling) to maximum 64 (severe activity avoidance due to concerns about falling)
Short FES-IAB: minimum 7 (no activity avoidance due to concerns about falling) to maximum 28 (severe activity avoidance due to concerns about falling)

Scoring with missing items:
If responses are missing on more than four items on FES-IAB (i.e.≥5), or more than two items (i.e.≥3) for Short-FES-IAB then the questionnaire scores cannot be used. If responses are missing on four or less for FES-IAB, or two or less on Short FES-IAB then it is possible to calculate a FES-IAB or Short FES-IAB score, respectively. To do this first calculate the total score of the items which have been completed. Divide that score by the number of items completed and then multiply by 16 (FES-IAB) or 7 (Short FES-IAB). The new total score should be rounded up to the nearest whole number to give the score for an individual.

The time to complete the FES-IAB (including the FES-I items) was automatically recorded in the online survey. Additionally, participants were asked several questions regarding the comprehensibility of the questionnaire at T2 (Table 2). Response options varied from 1 (certainly not) to 5 (certainly yes).

Analysis

Feasibility, interpretability and comprehensibility

We used descriptive statistics to provide insight into the feasibility, interpretability and comprehensibility of the FES-IAB, including time to complete, floor and ceiling effects, number of missing values at T1, and comprehensibility questions at T2. Time to complete the FES-IAB contained several outliers of a few days or more; we removed outliers that were 1.5 interquartile ranges away from the median (n=39). The smallest detectable change (SDC) was calculated for individuals ($SDC_{individual}$ = 1.96 x $SEM_{agreement}$ x √2) and the group (SDC_{group} = $SDC_{individual}$/√n).

$SEM_{agreement}$ = $\sqrt{\frac{MS_{observations} - MS_{residual}}{n} + MS_{residual}}$ with SEM representing the standard error of measurement and MS mean squares (de Vet et al., 2006; McGraw & Wong, 1996).

Validity

Spearman's correlations between the FES-IAB and 1-item activity avoidance, CaF (FES-I), 1-item CaF, ADL disability, and physical activity at T1 were calculated to assess construct validity. We expected strong correlations (0.7 or higher (Hinkle et al., 2003)) with 1-item activity avoidance, CaF (FES-I) and 1-item CaF; this refers to convergent validity. Furthermore, we expected low (0.3 to 0.5 (Hinkle et al., 2003)) to moderate (0.5 to 0.7 (Hinkle et al., 2003)) correlations with ADL disability and physical activity; this refers to divergent validity. Median FES-IAB scores and standard deviations were calculated according to subgroups of sex (men vs. women), age (<70 vs. >=70+), number of falls in the past six months (never vs. once or more), and mental health (MHI-5 score <=52 vs. >52). We expected FES-IAB scores to be higher for women, people of higher age, frequent fallers, and those with worse mental health (Denkinger et al., 2015). To assess known-groups validity, one sided Mann-Whitney U tests were performed to test for differences at T1. The internal structure of the questionnaire at T1 was

examined with confirmatory factor analysis. We used the following interpretation of good fit: comparative fit index (CFI) ≥ 0.95, Tucker Lewis index ≥0.95, root mean square error of approximation (RMSEA) ≤0.06 and standardized root mean square residual (SRMR) ≤0.08 (Hu & Bentler, 1999). We expected the FES-IAB to be unidimensional, as previously found for the FES-I (Yardley et al., 2005). Items were ordinal variables with a positive skew and the diagonally weighted least squares (DWLS) method with polychoric correlations was used to estimate model parameters. Test statistics were mean- and variance-adjusted.

Reliability

To assess internal consistency at T1, we calculated Cronbach's alpha. The interpretation of Cronbach's alpha has not been consistent, although a value of at least 0.7 has often been considered acceptable. As a test-retest statistic, we calculated the intraclass correlation coefficient from a two-way random effects model (ICC2 (Shrout & Fleiss, 1979)). We also plotted Bland Altman plots with 95% limits of agreement to visualize any systematic differences in scores between T1 and T2.

Medians (IQR) are reported for variables that are not normally distributed and positively skewed. Missing values of the FES-I, FES-IAB, Short FES-IAB, GARS ADL subscale and IPAQ were handled according to the rules of the scales (IPAQ Research Committee, 2005; Kempen et al., 2012; Prevention of Falls Network Europe, n.d.-a). For 1-item questions, <1% had missing values and no imputation was performed. Subsequently, persons with missing data on 1-item questions were disregarded in the validation analyses. All analyses were repeated for the 7-item Short FES-IAB, by making a selection of the data collected for the FES-IAB (items 2, 4, 6, 7, 9, 15, and 16). Analyses were performed in R, with packages haven 2.2.0, base 3.6.3, plyr 1.8.6, car 3.0-7, stats 3.6.3, dplyr 0.8.5, RVAideMemoire 0.9–77, lavaan 0.6–6, userfriendlyscience 0.7.2, BlandAltmanLeh 0.3.1, ggplot2 3.3.0 and psych 1.9.12.31. The R-script is available online at Open Science Framework (DOI: 10.17605/OSF.IO/MKPW9)

Results

The questionnaire was administered to 799 participants in the first wave (T1). Of the responders (n=744), 686 (response rate: 92.2%) completed the

questionnaire again (T2) (CentERdata, 2013). Reasons for non-response are not available, but non-responders at T2 did not differ significantly from responders regarding age, sex, living situation, educational level, perceived health, ADL disability, fall history, CaF, and avoidance of activities due to CaF.

Characteristics of participants at T1 are shown in Table 1. The median age of the participants was 68 and half of them were women. The majority of the participants had never fallen and participants had a relatively low level of CaF. Participants also had a low level of ADL disability, and about one-fifth rated their health as moderate or poor.

Table 1. Characteristics of participants at T1 (n=744).

Age (median, IQR[a])	68	9
Sex (n women, % women)	372	50.1
Living situation		
Alone (n, %)	228	30.8
Not alone (n, %)	513	69.2
Educational level		
Low (n, %)	377	50.8
Middle (n, %)	158	21.3
High (n, %)	207	27.9
Perceived health		
Poor (n, %)	9	1.2
Moderate (n, %)	148	20.1
Good, very good or excellent (n, %)	581	78.7
Activities of Daily Living disability[a] (median, IQR)	11	1
Fall history		
Never (n, %)	509	68.8
Once or more (n, %)	231	31.2
Concerns about falling[b] (median, IQR)	19	6
Avoidance due to concerns about falling[c] (median, IQR)	17	2

May not always add to 744 or 100% due to missing values.

[a] IQR = interquartile range.

[a] Measured with Groningen Activity Restriction Scale Activities of Daily Living subscale, range 11-44; higher scores imply greater disability.

[b] Measured with Falls Efficacy Scale - International, range 16-64; higher scores imply more concerns about falls.

[c] Measured with Falls Efficacy Scale – International Avoidance Behavior, range 16-64; higher scores imply more avoidance due to concerns.

Feasibility, interpretability and comprehensibility

The median time to complete the FES-IAB was 3.1 minutes (IQR 1.8). There were no missing values at T1 and two missing values at T2, one on item 15 and one on item 16. FES-IAB scores were positively skewed, with a range of 16-58 and a median of 17 (IQR 2). Floor effects were present, with 343 people (46.1%) having the lowest possible score of 16. Of these 343 people, 99 (28.9%) received the lowest score because they had no CaF. Two hundred and forty-four (71.1%) did not avoid activities, but were at least somewhat concerned about falling. The $SDC_{individual}$ was 5.12 and 2.34 for the FES-IAB and Short FES-IAB, respectively. The SDC_{group} was 0.20 and 0.09 for the FES-IAB and Short FES-IAB, respectively. Participants considered the questionnaire of appropriate length and questions and answer options were regarded as sufficiently clear (Table 2).

Table 2. Median scores for comprehensibility questions at T2 for the Falls Efficacy Scale – International Avoidance Behavior (n-685).

Question [a]	Median (IQR[b])
"Were questions sufficiently clear?"	5 (1)
"Were response options sufficiently clear?"	5 (1)
"Did the response options include the answer you wanted to give?"	5 (1)
"Did you find this part of the questionnaire too long?"	2 (2)
"If presented again, would you complete this part of the questionnaire again in the future?"	5 (1)

[a] Response options: 1 (certainly not) - 5 (certainly yes)
[b] IQR= interquartile range.

Validity

The FES-IAB strongly correlated with CaF and moderately with the 1-item activity avoidance, 1-item CaF, and ADL disability (Table 3). Correlation with physical activity was negligible. A similar pattern arose for the Short FES-IAB, although correlations for the FES-IAB were slightly less strong overall.

Responses differed significantly according to subgroups of age, sex, fall history and mental health for the FES-IAB and Short FES-IAB (Table 4). This demonstrates that both questionnaires are sensitive to group differences in demographic characteristics and fall risk factors.

Factor analysis confirmed unidimensionality. Fit indices indicate an excellent fit of a one-factor model with uncorrelated residuals for the FES-IAB

and Short FES-IAB (Table 5). All items load strongly on the underlying factor, with standardized loadings ranging from 0.80-0.96 for the FES-IAB and 0.76-0.98 for the Short FES-IAB.

Table 3. Spearman's rank correlation coefficients (95% CI) for the Falls Efficacy Scale – International Avoidance Behavior and Short FES-IAB at T1.

Variables	FES-IAB[a]	Short FES-IAB
Activity avoidance (1-item)	0.62 (0.56, 0.66)	0.58 (0.51, 0.64)
Concerns about falling (FES-I)	0.76 (0.72, 0.79)	0.67 (0.63, 0.71)
Concerns about falling (1-item)	0.57 (0.51, 0.63)	0.50 (0.43, 0.56)
Activities of Daily Living disability	0.50 (0.43, 0.56)	0.48 (0.41, 0.55)
Physical activity	-0.21 (-0.28, -0.14)	-0.23 (-0.30, -0.16)

[a] FES-IAB: Falls Efficacy Scale-International Avoidance Behavior.

Table 4. Medians of the Falls Efficacy Scale – International Avoidance Behavior and Short FES-IAB according to age, sex, fall history and MHI-5 score at T1.

Subgroups	n	FES-IAB[a] median (IQR[b])	Short FES-IAB median (IQR)
Age			
<70	432	16.0 (2.0)*	7.0 (0.0)*
=>70	311	17.0 (4.0)	7.0 (1.0)
Sex			
Men	371	16.0 (2.0)*	7.0 (0.0)*
Women	372	17.0 (3.0)	7.0 (1.0)
Fall history			
0 falls	635	16.0 (2.0)*	7.0 (0.0)*
1 or more falls	104	18.0 (5.0)	7.0 (2.0)
Mental Health Inventory			
<=52[c]	71	18.0 (5.5)*	8.0 (2.0)*
>52	666	17.0 (2.0)	7.0 (1.0)

Numbers may not always add up to 744 due to missing values.
[a] FES-IAB: Falls Efficacy Scale-International Avoidance Behavior.
[b] IQR= interquartile range.
[c] <=52: lower mental health. >52: higher mental health.
*p<0.01 for the Mann-Whitney U tests

Table 5. Fit indices and standardized factor loadings for the confirmatory factor analysis of the Falls Efficacy Scale – International Avoidance Behavior and Short FES-IAB at T1.

Fit indices and factor loadings		FES-IAB[a]	Short FES-IAB
Comparative fit index		0.993	0.997
Tucker-Lewis Index		0.992	0.996
Root mean square error of approximation		0.035	0.027
Standardized root mean square residual		0.053	0.040
Item standardized factor loading			
	1	0.87	
	2	0.82	0.80
	3	0.94	
	4	0.80	0.76
	5	0.89	
	6	0.96	0.98
	7	0.84	0.84
	8	0.90	
	9	0.88	0.88
	10	0.91	
	11	0.84	
	12	0.91	
	13	0.92	
	14	0.91	
	15	0.87	0.85
	16	0.95	0.94

[a] FES-IAB: Falls Efficacy Scale-International Avoidance Behavior.

Reliability

The internal consistency of the FES-IAB was high. Cronbach's alpha was 0.92 (95%CI: 0.92, 0.93). Test-retest reliability was good, as indicated by an ICC of 0.85 (95% CI: 0.83-0.87) for the FES-IAB and 0.83 (95% CI: 0.81-0.85) for the Short FES-IAB. For the Short FES-IAB, Cronbach's alpha was 0.82 (95%CI: 0.80, 0.84). In the Bland-Altman plots (Appendix A), the vast majority of T1-T2 differences fall around 0, indicating few systematic differences between T1 and T2.

Discussion

The FES-IAB was developed to efficiently assess activity avoidance due to CaF, by making use of the internationally accepted and validated FES-I. In this study, the FES-IAB and Short FES-IAB both demonstrated good construct validity,

reliability, feasibility, and comprehensibility. Altogether, correlations with other variables were in line with expectations. Correlations of the 1-item avoidance question with the FES-IAB and Short FES-IAB were lower than expected based on them assessing the same construct. However, FES-IAB scores were skewed and the limited variability in responses due to floor effects may have affected correlations. Additionally, single questions are much less complex than scales, which may account for moderate correlation. FES-IAB scores were higher for women, people of higher age, frequent fallers, and people with lower mental health, as expected based on previous studies (Denkinger et al., 2015). Confirmatory factor analysis confirmed FES-IAB and Short FES-IAB are unidimensional, with excellent fit and all items loading highly on one underlying factor. The test-retest reliability was good for both questionnaires. Furthermore, the internal consistency of the FES-IAB was high – 0.92 (Cronbach's alpha) – a sign that the questionnaire may contain redundant items (Tavakol & Dennick, 2011). After removing some items of the FES-IAB, Cronbach's alpha of the Short FES-IAB was 0.82.

Compared to other studies assessing instruments for activity avoidance due to CaF, we used a very large sample with a more equal distribution between men and women. The FES-IAB demonstrated high internal consistency, similar to what was previously found in studies on the modified SAFFE (MSAFFE) and FFABQ and in some SAFE studies (Acaröz Candan et al., 2020; Jonasson et al., 2014; Lachman et al., 1998; Liu & Ng, 2019; Nilsson et al., 2010; Yardley & Smith, 2002). In general, the FES-IAB's ICC indicated good reliability and the ICC was similar to or slightly lower than those reported for the SAFE, MSAFFE, and FFABQ (Acaröz Candan et al., 2020; Jonasson et al., 2014; Landers et al., 2011; Liu & Ng, 2019; Nilsson et al., 2010). However, comparing test-retest reliability is impeded by studies using different types of ICC's and the current study using a longer retest time and a much larger sample for the retest analysis. The SDC, presenting the amount of change in an individual that is beyond changes due to measurement error, was about five and two for the FES-IAB and Short FES-IAB, respectively. The SDC was smaller than one for both scales on a group level. The FES-IAB performed no less than other instruments regarding convergent, divergent and discriminative validity (Acaröz Candan et al., 2020; Delbaere et al., 2004; Hotchkiss et al., 2004; Jonasson et al., 2014; Lachman et al., 1998; Landers

et al., 2011; Liu & Ng, 2019; Nilsson et al., 2010; Talley et al., 2008; Yardley & Smith, 2002). Furthermore, the current study collected information on feasibility and comprehensibility and the FES-IAB showed quick to administer (median 3 minutes) and comprehensible. Overall, the FES-IAB performs at least equally well as other measures of activity avoidance. As an extension of the widely used FES-I, the FES-IAB can increase data collection efficiency, decrease participant burden, and facilitate comparison between studies. It could also serve as a screening instrument in clinical practice.

This study also has limitations. First, responsiveness to change and the minimally important difference (MID) were not assessed. Future studies need to show if the FES-IAB is sufficiently able to detect clinically important change (e.g.in an intervention study). Second, the comprehensibility of the questionnaire was only assessed at T2. Third, this study was performed on a specific population of relatively young older adults that filled out questionnaires online and the FES-IAB demonstrated floor effects. Whether the scale is not sensitive enough in this population or whether this population has low levels of CaF is not clear. We cannot externalize our results to older or more impaired populations. Future studies that evaluate the responsiveness of both questionnaires could be performed, as well as cross-cultural validations and studies in older or more impaired populations.

In summary, both versions of the FES-IAB proved valid and reliable for measuring activity avoidance due to CaF in community-dwelling older people. The Short FES-IAB provides an excellent alternative when the setting requires a shorter questionnaire, but researchers and clinicians should carefully consider their goals when choosing an instrument. Both instruments may help to shed light on the understudied behavioral consequences of CaF.

Declaration of competing interest

None.

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Supplementary materials

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Appendix A – Bland-Altman plots

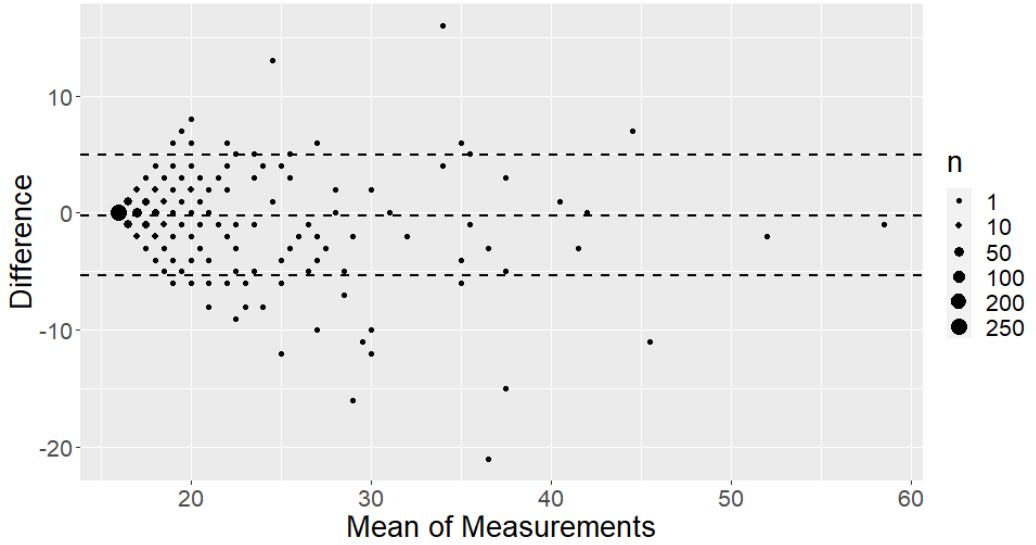


Figure 1. Bland Altman plot of differences in Falls Efficacy Scale – International Avoidance Behavior sum scores between T1 and T2, with 95% limits of agreements. Mean of measurements represents the mean of the sum score at T1 and T2.

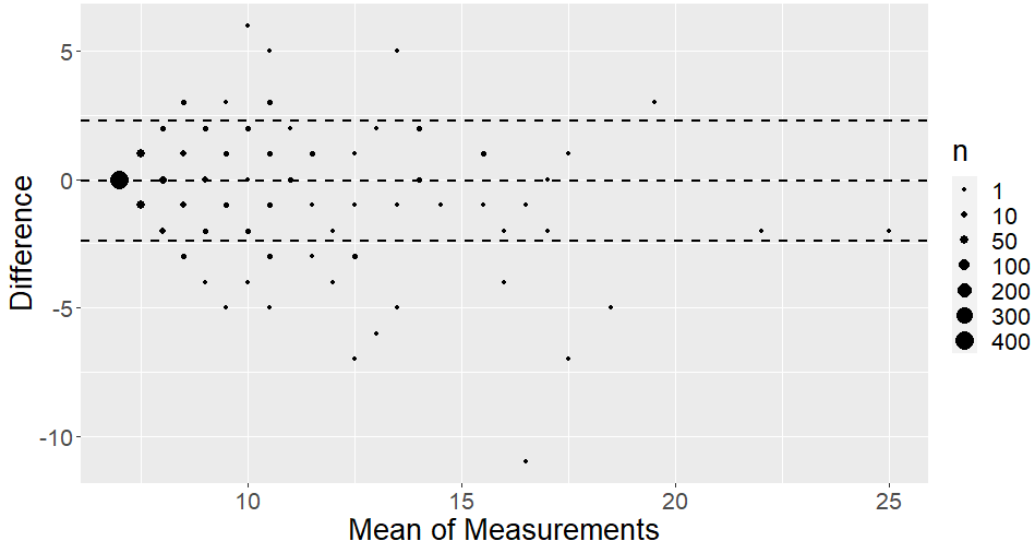
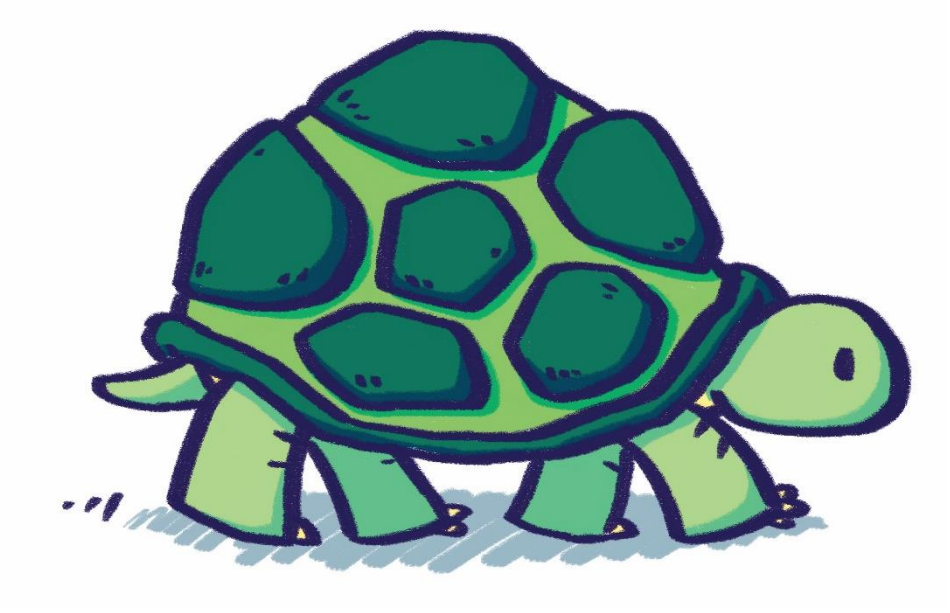


Figure 2. Bland Altman plot of differences in Short Falls Efficacy Scale – International Avoidance Behavior sum scores between T1 and T2, with 95% limits of agreement. Mean of measurements represents the mean of the sum score at T1 and T2.



Chapter 6: General discussion

Preface

Fear of falling (FoF) - also reported as, for example, concerns about falling (CaF) - is common in older adults. In the Netherlands, about half of the community-dwelling older people are afraid to fall (Halfens et al., 2016; Zijlstra et al., 2007). It is associated with activity avoidance, decreased physical functioning, social isolation, loss of independence, reduced quality of life and early admission to nursing homes (Cumming et al., 2000; Delbaere et al., 2004; Meulen et al., 2014). Effective interventions achieving small to moderate effects on FoF are available (Chua et al., 2019; Jung et al., 2009; Sherrington et al., 2019), but leave room for further improvement. In order to optimize interventions, identifying which factors contribute towards effects is essential. In the first part of this thesis, an explorative approach was applied to study factors that potentially influence intervention effects on FoF. The aims of these chapters were: 1) to explore which overarching intervention characteristics are effective in reducing FoF in community-dwelling older people; 2) to explore the association between specific intervention components and the reduction of FoF; and 3) to explore whether participant characteristics are moderators of the effects of cognitive behavioral interventions on CaF in older community-dwelling adults.

The second part of this thesis addressed activity avoidance due to FoF. While FoF has been gaining attention in research over the past decades, activity avoidance due to FoF is understudied. Due to FoF, older adults can restrict themselves in performing all kinds of activities and this can lead to poor physical performance and loss of independence (Deshpande et al., 2008). Several instruments for activity avoidance due to FoF exist, but there is no widely used standard. The Falls Efficacy Scale – International Avoidance Behavior (FES-IAB) is a questionnaire that builds upon an internationally used measure for concerns about falling (CaF); the Falls Efficacy Scale – International (FES-I). The second part of this thesis aimed to assess the psychometric properties of the FES-IAB and shortened FES-IAB in community-dwelling older people.

In the current chapter, the main findings of the four studies in this dissertation are described. Furthermore, some theoretical and methodological considerations, and implications are discussed. The chapter finishes with an overall conclusion.

Summary of findings

Part 1: Unravelling interventions

The effects of interventions on FoF may depend on several factors. First of all, effects of interventions may vary because of their content, i.e. intervention types such as strength training, home modification or education may be more or less suitable to help older adults manage their FoF. Effects may also depend on other characteristics. For example, older adults may respond better to certain delivery methods or supervisors with specific backgrounds. An overview of all types of interventions and their characteristics was lacking in the current literature on FoF. Furthermore, there was little information on the association of intervention characteristics with intervention effects. Therefore, we presented these details of 50 interventions in a systematic review and meta-analysis. Overall, interventions achieved a small to moderate effect when pooled together (Chapter 2). With meta-regression, effects of interventions of a certain intervention type were compared to the effects of interventions that were not of that type. Regarding the types of intervention, only holistic exercise interventions, such as Pilates interventions or yoga interventions, were significantly associated with a greater reduction in FoF. Similarly, all interventions with a certain characteristic were compared to all interventions without that characteristic. Most investigated characteristics were not associated with effects, but interventions that were supervised by a Tai Chi instructor or delivered solely in a community setting were significantly more effective than those that were not. Furthermore, interventions that were tailored, delivered solely at home, or delivered with written materials, were significantly less effective than interventions without these characteristics.

Categorizing interventions into intervention types based on their most prominent features may be too simplistic, because interventions usually consist of multiple components that can contribute towards effects. Hence, in Chapter 3 we updated the review from Chapter 2 and focused on the content of interventions in more detail. Sixty-eight different intervention components were identified in 85 interventions. Components included content elements, such as strength training or education, but also techniques that could be applied, such as increasing the level of difficulty. Results of 49 interventions could be

analyzed with meta-regression. Interventions with holistic exercise and components that are typically found in holistic exercise interventions - such as meditation or body awareness - were more effective than interventions without these components. Interventions with self-monitoring, or balance exercise were less effective compared to those without these components. The identified significant characteristics and components can be considered in the design and optimization of treatments to reduce FoF, although they should be examined further in future studies.

Another important factor to consider for intervention optimization is who the intervention is delivered to, i.e. the participants. Some people may benefit more from interventions than others and insight into participant characteristics that influence the effects of interventions on FoF could help target or adapt interventions, thereby increasing effectiveness and reducing costs and participant burden. A Matter of Balance – Netherlands (AMB-NL) and A Matter of Balance – Home (AMB-Home) are the group and individual version, respectively, of a cognitive behavioral program developed for people with CaF and activity avoidance. They have both demonstrated effectiveness in randomized controlled trials (RCTs) and AMB-NL was also effective in daily practice. By using mixed models, we re-analyzed the data of the RCTs and found that several demographic, health and socio-cognitive variables moderated the effects of AMB-NL and AMB-Home (Chapter 4). The analyses of AMB-NL show an increase in CaF in the control group for worsening cognitive status and for increasing levels of symptoms of depression, ADL disability, and perceived consequences of falling (damage to identity subscale). However, this is not the case for intervention participants. This may imply that AMB-NL acted as a buffer for the detrimental effects of these variables on CaF. In addition, in AMB-NL, there was a significant intervention effect for those in fair health, but not for those in good health. An effect of perceived health was also seen for AMB-Home. The intervention was effective for those in fair health, but not those in poor health. Furthermore, the intervention effects of AMB-Home differed between categories of the moderators living situation (i.e. alone or not) and fall history (i.e. never, once or more than once). Notably, none of the moderators in the models with elaborate adjustments were significant on the long term, i.e. 1 year and 7 months after the AMB-NL and AMB-Home intervention, respectively.

Nevertheless, these results may guide modifications to recruitment of intervention participants and further optimization of the interventions.

Part 2: Measuring activity avoidance due to fear of falling

The Falls Efficacy Scale-International Avoidance Behavior (FES-IAB) is a questionnaire for measuring activity avoidance due to CaF. It builds upon the FES-I, which is an internationally used measure for CaF during a variety of activities. For each of the 16 items in the FES-I, people are also asked to what extent they avoid the activity due to their CaF. The psychometric properties of FES-IAB had not been assessed. A sample of community-dwelling older adults of the Longitudinal Internet Studies for the Social Sciences (LISS) panel completed the FES-IAB twice, with one month in between ($n^{wave\ 1}$=744, $n^{wave\ 2}$=686). Activity avoidance was common, 53.9 % of participants avoided at least some activities due to their CaF. The 16-item FES-IAB demonstrated floor effects, but otherwise showed good construct validity, internal consistency, test-retest reliability, feasibility and comprehensibility (Chapter 5).

Theoretical considerations

Fear of falling

Over time, several constructs have been placed under the header FoF. At first, FoF was only used to describe intense *fear* that could develop after a fall (Bhala et al., 1982; Murphy & Isaacs, 1982). In 1990, a scale was developed to measure FoF: the Falls Efficacy Scale (FES). The questionnaire conceptualized FoF as “low perceived self-efficacy at avoiding falls during essential, nonhazardous activities of daily living."(Tinetti et al., 1990). Thus, *self-efficacy* or *self-confidence at avoiding falls* was introduced and placed under the header FoF. Later, *concern* was also placed under FoF, when FoF was defined as “a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing” (Tinetti & Powell, 1993). Then the Activities-specific Balance Confidence scale was developed, which assessed *confidence at not losing balance* (Powell & Myers, 1995). Even more instruments exist, referring to concepts such as worry or feared consequences of falling (Lachman et al., 1998; Yardley & Smith, 2002). These are sometimes also grouped under FoF as umbrella term. One of the latest instalments in FoF measurement is the Falls

Efficacy Scale – International (FES-I). The FES-I measures concerns, but still contains efficacy in its name, in order to acknowledge that it was based on the original FES.

Thus, FoF has been used to refer to a range of cognitive and affect-based constructs, such as falls self-efficacy, balance confidence, and fear, worry and concern about falling. This reflects how, over time, different interpretations arose and authors chose to conceptualize and measure psychological aspects related to falls in ways that fitted their aims and research. Putting all of these constructs under the umbrella term 'Fear of Falling' contributed towards more visibility and acknowledgement of research about psychological fall aspects. However, the lack of a single, clear definition of the term "Fear of Falling" may be problematic. Constructs such as fear, concern and confidence are related, but not necessarily the same (Hadjistavropoulos et al., 2011; Jørstad et al., 2005). Furthermore, in the preparation of this dissertation, we came across studies in which authors use the different constructs interchangeably in their texts, but appear to measure only one. Additionally, authors mention constructs that are actually not measured with the scales that they refer to. This may cause confusion among readers about what is actually measured and complicates meta-analytical work and other data syntheses. In this thesis, FoF was approached as broadly as possible and because of the great variety of conceptualizations of FoF in literature, several constructs were added together under the heading FoF for the meta-analyses (Chapter 2 and 3).

Reducing or managing fear of falling?

In Part 1 of the dissertation, characteristics and components of interventions (Chapter 2 and 3) and characteristics of participants (Chapter 4) were evaluated in relation to intervention effectiveness. In these studies, 'effectiveness' was used to refer to a reduction in FoF. However, a reduction in FoF may not always be appropriate. First of all, reducing FoF may be unfeasible. Although we can support older adults to age as healthily as possible, some physical deterioration is likely to occur (World Health Organization, 2020). This decline in physical functioning can be accompanied by increased levels of FoF. Consequently, instead of a reduction, a maintenance of the current FoF level may already be valuable for some older adults. Second, reducing FoF can be undesirable. If FoF

is the result of a rational appraisal and matches the actual (physical) fall risk, it may lead to an appropriate amount of protective behavior (Delbaere et al., 2010; Tennstedt et al., 1998; Zijlstra, 2007). In this case, FoF is actually beneficial and reducing the level of FoF may be harmful. Nevertheless, mismatches between FoF and the physical fall risk can also occur. When FoF is excessive and irrational, it may lead to unnecessary activity restriction. Alternatively, disproportionally low levels of FoF may lead to risky behavior (Delbaere et al., 2010). Delbaere and colleagues analyzed data of a sample of 500 older adults found that mismatches between the level of FoF and the physical falls risk occurred in 31% of the sample (Delbaere et al., 2010). Depending on whether the FoF is too high or low in relation to their physical falls risk, FoF may need to decrease or increase for these individuals. Hence, the aim of an intervention needs to be aligned with the older person participating in the intervention. Rather than aiming for a reduction in FoF for all individuals, it is important that older adults can make a realistic estimation of their fall risk and manage their FoF accordingly (Tennstedt et al., 1998; Zijlstra, 2007).

Measuring avoidance behavior in addition to falls and fear of falling

The field of fall prevention is still evolving. Falls have been on the research and healthcare agenda for some time and more recently FoF is being recognized as a problem. However, the behavioral consequences of falls and FoF have not received much attention so far. In the reviews in this thesis, few included studies assessed activity avoidance due to FoF. This is unfortunate, because activity avoidance due to FoF is an important outcome to assess. It is associated with several negative consequences, such as poor physical performance and loss of independence (Delbaere et al., 2004; Deshpande et al., 2008). Additionally, there are advantages to assessing falls, FoF and activity avoidance due to FoF as a set. First of all, by considering outcomes of interventions on all three aspects, it can be assessed whether they are in balance. Interventions should not lead to positive outcomes such as less falls, while simultaneously leading to negative outcomes such as increased avoidance of activities or increased FoF (Zijlstra, 2007). Second, if each study would assess all three outcomes in a standardized way, this would facilitate the study of associations and underlying causal

mechanisms, increase comparability between studies and facilitate meta-analysis (Mokkink et al., 2016).

Validated, appropriate methods are available for falls, such as fall calendars (Lamb et al., 2005). If researchers or healthcare professionals want to assess CaF, a widely used and validated measure is available by means of the FES-I (Prevention of Falls Network Europe, n.d.; Yardley et al., 2005). Now, a valid and reliable measure is available for avoidance behavior as well. The FES-IAB adds questions about activity avoidance to the FES-I. Therefore, data collection is efficient and the participant burden is lower than other existing measures for activity avoidance due to FoF. Additionally, as the FES-I is already applied in different cultures and settings, the FES-IAB also has potential to facilitate international comparison of studies about activity avoidance due to FoF.

The interplay between intervention factors

In the introductory chapter, a schematic overview of factors that may influence intervention effects on FoF was presented (Chapter 1, Figure 1). Within a context, an intervention – including its components and characteristics – can achieve an effect on FoF. Furthermore, characteristics of supervisors and participants may influence the effects of an intervention. This schematic overview disregards the interplay between factors. The relationships between intervention effects and intervention characteristics, components, participants, and supervisors are likely to be much more complex. For example, there may be interaction within the intervention factors, e.g. individual components can interact and thereby strengthen (or weaken) an intervention effect. In addition, there can be interaction between factors, e.g. components could interact with characteristics or participants could interact with supervisors. In addition to direct associations, indirect and complex reciprocal connections between the various factors may be possible, resulting in different 'pathways' to reach an intervention effect. There is not yet much theory available that sheds light on these complexities, also not for the specific outcome FoF. However, we may be able to formulate hypotheses. Testing such hypotheses can help to build a solid theoretical foundation to support the development of effective interventions. The first step for this was made within this thesis. By creating an overview of

studies, there is more insight into what interventions for FoF look like and what factors could play a role. Furthermore, the explorative findings of this thesis can be serve as base for research questions and hypotheses. For example, the findings indicated that interventions with self-monitoring are less effective than interventions that do not contain this component. This raises the question whether a component such as self-monitoring may be more effective when delivered together with other components, such as goal setting and feedback.

Methodological considerations

By using meta-analytical techniques (Chapter 2 and 3), secondary data-analysis (Chapter 4) and an openly available dataset (Chapter 5), this dissertation provides a case example of how to use previously collected data in an innovative way. Without gathering new data on participants, we were able to collect valuable information about the influence of intervention factors and the psychometric properties of an instrument. Furthermore, by combining various research methods, we obtained both a broad and detailed perspective on factors that may contribute to intervention effects. The meta-analyses allowed us to examine a range of characteristics and components across many interventions simultaneously. With secondary data analysis, we were able to provide more in-depth information about participant characteristics as moderators of cognitive behavioral interventions. However, there are also disadvantages to our approach. Some of these are outlined below.

Reporting to facilitate meta-analysis

A systematic review is, by nature, dependent on the reporting in published literature. Many authors have observed that the reporting on interventions is insufficient to facilitate meta-analytical work (Knittle, 2015). In the systematic reviews and meta-analyses in this thesis (Chapter 2 and 3), reporting generally lacked in several areas. First of all, most articles did not report on actual intervention adherence. Subsequently, characteristics and components could only be analyzed in the way they were planned, not how they were actually delivered. Second, lack of detail on intervention content made it hard to determine whether some intervention components were not included in the intervention or simply not described. For example, it is likely that many of the included exercise interventions included a *demonstration* of the different

exercises and some *education* on why the exercises were important. However, these components were often not reported. Notably, there was considerable variation in the level of detail reported in included articles and intervention descriptions were especially lacking in the older articles. Potentially, efforts to improve reporting, such as the TIDieR checklist, have contributed to more complete intervention descriptions (Hoffmann et al., 2014). Third, most descriptions did not include any information on parameters for effectiveness. Some intervention components are only effective under certain conditions (Peters et al., 2015). For example, when feedback is given, the feedback should be specific (Bartholomew et al., 2006; Kok et al., 2016). Whether some components were not effective or whether their parameters were not met is unknown. Overall, poor reporting results in uncertainty and limitations, meaning that the results from the meta-analyses should be interpreted and applied to practice with caution.

Interpretation of effects

Another point of attention concerns the interpretation of effect sizes and effects. In the systematic reviews and meta-analyses in Chapter 2 and 3, standardized mean differences (Cohen's d) were used. Cohen's d is a common way to measure effect size and according to the interpretation of Cohen, some interventions reached large effects. Furthermore, some characteristics and components were associated with large increases or decreases in effects. Nevertheless, we cannot be certain whether such effects were also large to older individuals (i.e., perceived relevance). When calculating a standardized mean difference, the effect is standardized by dividing the difference between groups by the pooled standard deviation (Higgins & Green, 2011). Assigning meaning to such a value can be challenging and, therefore, the interpretations put forward by Cohen are still just a rule of thumb. This also touches upon another point, which is the interpretation of the effects as measured by the FES-I and FES-IAB. We know what amount of change in the scores of these instruments is likely to be a true change (Hauer et al., 2011) (Chapter 5). This is known as the smallest detectable change. However, there are very few studies that report on the minimal important change, which provides information on what amount of change is a relevant or important change to older adults. This

causes issues with the interpretation of results. For example, in Chapter 4, we evaluated whether participant characteristics moderated effects of two cognitive behavioral interventions on CaF. We found several significant moderators, but we have no information on whether such moderating effects would also be relevant for older adults in their daily life.

An explorative approach

The studies in Chapter 2, 3 and 4 were exploratory. This has several implications. First of all, there is a risk of type 1 and type 2 error. We evaluated a large number of associations, for which a multiple testing correction can be applied to reduce the risk of type I error. This usually results in a much lower significance level than the commonly applied level of 0.05. On the other hand, when exploring associations and interactions, a significance level of 0.1 is sometimes applied to avoid missing out on a potentially relevant association. Especially when testing for interaction (Chapter 4), sample sizes may be too small and the study may be underpowered, thereby increasing the risk of type II error. We considered both these issues and found the middle ground by applying a significance level of 0.05 in our statistical tests. Nevertheless, results should be interpreted with caution. Second, we did not test specific hypotheses. Rather, the studies in Part 1 can be seen as hypothesis generating. When we consider how scientific evidence is accumulated, meta-analyses and reviews are often put at the top of the evidence pyramid as the ultimate evidence (Murad et al., 2016). However, they can also be thought of as a part of a continuous process of intervention optimization. The Multiphase Optimization Strategy (MOST) developed by Collins and colleagues describes how interventions can continuously go through three different phases (Collins, 2018). In the preparation phase, the groundwork for optimization is laid. Candidate components are identified, a conceptual model of an intervention is made and pilot tests are conducted. In the second phase, small experiments are conducted to build an optimized intervention. When the optimized intervention is expected to be effective, a large scale RCT is performed in the evaluation phase, after which further optimization may start. Part 1 of the thesis is explorative, but contributes to the preparation phase of intervention optimization. Systematic reviews, meta-analyses and secondary data analyses are suitable methods to identify candidate components. They are

a good first step in the investigation of effective intervention factors for FoF, which had not been previously attempted. As mentioned in the theoretical considerations, the detailed overview of interventions and explorative results in this thesis may guide the formulation of hypotheses. These can be tested in experimental settings or in more complex meta-analytical models (Peters et al., 2015).

Replicability

Science depends on replication to validate results. In the preparation of the datasets for this thesis, we had to make many decisions about our data extraction and analysis. For example, we had to decide how to code intervention components (Chapter 3), what data from studies to use for the calculation of Cohen's d (Chapter 2 and 3), and which variables to correct for in our models (Chapter 4). This gives rise to a replicability problem, which is nicely illustrated by "the Garden of Forking Paths". Originally a work of fiction published in 1951, the statistician Andrew Gelman uses this title to describe how researchers have to make countless decisions in the preparation (and execution) of data analysis (Gelman & Loken, 2014). There is a certain degree of flexibility that researchers have when taking these decisions. This has also been referred to as researcher degrees of freedom (Wicherts et al., 2016). Researchers can be unaware that making a small decision and setting out on a different path may have a big impact on the final results, because rather than "fishing" for significant results, it can happen due to a reasonable decision process that depends on the data (Gelman & Loken, 2014). Ways to tackle this issue include pre-registration and having other researchers independently analyze the same data. A strong point of this thesis is that we pre-registered several of the studies (Chapter 2, 3 and 4) and made its syntaxes publicly available. We also published the underlying data when possible. Therefore, the analyses can be scrutinized and validated by other researchers. Furthermore, for decisions not included in the pre-registrations, we used a consensus approach, in which several of the co-authors had to reach agreement before proceeding with our analyses. By documenting these decisions, we tried to enhance transparency. Additionally, we applied sensitivity analyses to see whether some of our methodological choices influenced results and the results seem to be robust. However, the application of sensitivity

analysis is limited, and it is still likely that there are more ways in which our analyses could have been approached.

Implications and recommendations

Further research

Much remains to be investigated in the field of FoF and several general suggestions for further scientific research into interventions for FoF can be made. Firstly, there are still very few interventions that are specifically aimed at FoF. In Chapter 2, only 7 of 50 studies included in the meta-analysis assessed FoF as a primary outcome. It is likely that interventions that have been specifically developed to address FoF are more effective, but we are currently unable to accurately assess this because of a lack of studies. Secondly, the systematic review in Chapter 3 revealed that some intervention components may be understudied. For example, we could include just one study with the component hip protectors. More research is needed on these understudied components to properly investigate their effectiveness. Thirdly, long-term evaluations were available for only a few studies (Chapter 3). More long-term evaluations may be necessary, because what initiates changes is not necessarily what helps to maintain changes (Samdal et al., 2017). Furthermore, some intervention components may need time before their effects become evident (Lamb et al., 2005).

The list of factors studied in this thesis was not exhaustive and there may be possibilities for research into other factors that influence intervention effects. This thesis did not take into account the context in which interventions are given. For example, cognitive behavioral group interventions may be less suitable in cultures in which thoughts and feelings are not easily shared with others. In addition, in group interventions, individuals also interact with others and this may influence their experiences, progress and intervention effects (Beauchamp et al., 2007). These additional factors can be investigated with (small scale) experiments or similar methodologies as in this thesis can be applied. For example, Rains and Young (Rains & Young, 2009) performed a meta-analysis and found that group size is a significant moderator of the effects of computer-mediated support groups on social support and quality of life. Future studies may also take into account interactions between intervention factors,

such as between intervention characteristics and components. The thesis was a first exploration and such interactions were not taken into account.

Following the theoretical and methodological considerations, a number of recommendations related to measurement can be specified. Avoidance of activities due to FoF is rarely assessed and should become part of a standard set of outcomes that are measured in fall-related research, together with falls and FoF. Among other things, this would facilitate comparison of studies and the study of associations and causal mechanisms (Lamb et al., 2005). Activity avoidance due to CaF can be measured with the FES-IAB, which was validated for the first time as part of this thesis and demonstrated promising results in a Dutch sample of relatively healthy community-dwelling older adults. Further validation studies, in other populations, are recommended. Furthermore, there is little information on what changes in FoF and associated activity avoidance are important to older adults, and studies on the minimally important change of the FES-I and FES-IAB would facilitate interpretation of scientific findings. A last recommendation regarding measurement involves the conceptualization of FoF. In scientific literature, different constructs, such as worry about falling, fear about falling and balance confidence are placed under the term 'fear of falling'. This can cause confusion among readers and impede meta-analysis (Mokkink et al., 2016; Moore & Ellis, 2008). Reaching and implementing consensus about conceptualizations and measurement of FoF may be difficult, because the different conceptualizations represent different interpretations. Authors may prefer to keep using the definitions and measurement instruments they feel are best. An alternative that can be considered is the development of decentralized construct taxonomies (DCTs). DCTs contain definitions of constructs, instructions for construct measurement and coding in systematic reviews (Peters, 2020). Although the different interpretations of FoF would still exist, confusion could be reduced if authors would use - and refer to - DCTs.

The final recommendations for research concern reporting. First, intervention descriptions need to improve. Good intervention descriptions are necessary to allow replication and to support meta-analytical work (Knittle, 2015). Checklists such as the 'template for intervention description and replication' (TIDieR) and the 'workgroup for intervention development and evaluation research' (WIDER) checklist have contributed to improvements

(Albrecht et al., 2013; Hoffmann et al., 2014). However, many intervention descriptions are still not sufficiently detailed to extract intervention components. An online database with detailed descriptions of interventions can be considered. The development of such a database could include attempts to retrieve missing details on older interventions. Second, information on the dose and adherence is often missing. Although these details may be reported separately in process evaluations, not all investigations include a process evaluation and information is rarely reported on the detailed level of intervention components. An example of a detailed process evaluation is the process evaluation of AMB-Home by Dorresteijn and colleagues (Dorresteijn et al., 2013). For each session, the duration of and adherence to each intervention component is reported. Such information is very useful when interpreting effects of studies, but collecting this information also costs a lot of time and can be burdensome to participants and intervention facilitators. Furthermore, there can be problems with self-report and social desirability bias (Dorresteijn et al., 2013). It is recommended that more practical pointers are developed on how to report delivered dose and adherence on the level of components. Third, new mechanisms for the reporting of intervention effects on FoF need to be developed. In all studies included in the systematic reviews (Chapter 2 and 3), changes in FoF were reported on a group level. However, FoF can result in protective behavior, and it can differ per individual whether FoF should be maintained, decreased or increased. Therefore, studies should not only report average changes in FoF. Rather, it should be considered whether participants reached an appropriate level of FoF that matches their physical fall risk.

Practice

Fear of falling is common among older adults (Scheffer et al., 2008). Given its serious consequences, we need effective strategies to deal with FoF in daily practice. Many different types of interventions achieve some effect on FoF (Chapter 2 and 3) and health professionals can consider implementing some of them as they are. However, for many interventions that show small or moderate effects, optimization may be possible. Therefore, we investigated numerous factors and tried to pinpoint which of them were associated with effects on FoF. The results indicate that holistic exercise, meditation, body awareness,

supervision by a Tai Chi instructor and delivery in a community setting could be contributing significantly towards a reduction in FoF. These characteristics and components are all common in holistic exercise types such as Tai Chi, yoga and Pilates. The studies in this thesis were a first exploration and - taking into account the theoretical and methodological considerations - more evidence is needed to confirm these results. However, there are indications that holistic exercise types can also yield benefits for outcomes such as strength, mobility, balance, and falls. Consequently, health professionals may want to consider implementing them (Fernández-Rodríguez et al., 2021; Youkhana et al., 2015; Zhong et al., 2020). There are several ways in which this could be done. For instance, when FoF is diagnosed by health professionals, a referral to local Tai Chi or yoga classes can be made. Such classes could also be added to an already available intervention, in order to reach an additive or synergistic effect. For example, in a study by Huang et al., participants that received cognitive behavioral therapy with Tai Chi had significantly lower fear of falling than the participants that only received cognitive behavioral therapy (Huang et al., 2011). This illustrates one of the advantages of investigating intervention components. By adding components to interventions, an optimal intervention mix can be created, in which the context can also be taken into account. Although effectiveness is a prerequisite, interventions should also be cost-effective and practical, acceptable, safe and affordable to individuals (Michie et al., 2014). Which of these criteria is prioritized as most important may be highly dependent on the context. For example, yoga classes may be too expensive, or Tai Chi classes may not be available in some areas. Another recommendation for practice is to take special care when offering highly tailored interventions or interventions with self-monitoring, as meta-regressions demonstrated that these components may decrease effectiveness (Chapter 3).

This thesis contains valuable information for AMB-NL and AMB-Home; two interventions for people with CaF and activity avoidance that are currently offered in the Netherlands (Trimbos, n.d.). Based on previous studies, a face-to-face personalized recruitment by home care professionals has been recommended to prevent withdrawal (Zijlstra et al., 2009). The analysis of moderators of AMB-NL (Chapter 4), indicated that special attention may also need to be payed to people with high levels of symptoms of depression, ADL

disability, and feared consequences of falling, and those with poor cognitive status in recruitment procedures. These individuals may be hard to reach, but participation may be extra beneficial for them. Furthermore, living situation and fall history were moderators of AMB-Home (Chapter 4). Those that live alone may need more intervention specific support, and more attention for safe behavior may be beneficial for frequent fallers. When adaptations are made to the interventions, this may influence effects in unexpected ways and it is important to keep evaluating any changes that are made. Although starting a new RCT may be unfeasible, other small scale evaluations (in terms of number of participants), such as sequential assignment trials could be used to generate more and different types of evidence (Collins et al., 2007). In addition, qualitative evidence and process evaluation may be complementary to ensure the interventions are still acceptable and feasible.

Lastly, those working in clinical practice may benefit from application of the FES-IAB. Activity avoidance due to FoF can limit older adults in their independence. Furthermore, falls, FoF and activity avoidance due to FoF should be in balance, i.e. interventions should not produce improvements in one aspect, but create deteriorations in others. Therefore, it is important that all three are measured simultaneously. The FES-IAB is a valid and reliable instrument that is quick to administer, especially since it can be used together with the FES-I (Chapter 5). Therefore, it has potential to become part of routine administration, e.g. for screening purposes, tracking of treatment progress or goal setting.

Overall conclusion

In the first part of this thesis, factors that influence effects of interventions on FoF were explored. First, several intervention characteristics and components that have the potential to improve or diminish effects of interventions on FoF were identified. These may be considered in the development or optimization of interventions and can provide input for hypotheses in future studies. Second, a number of health, demographic and socio-cognitive participant characteristics moderated the effects of cognitive behavioral interventions on CaF. These participant characteristics should be taken into account in recruitment and where possible, adaptations should be made to accommodate groups that

benefit less. Any adaptations to the interventions may influence effects. Therefore, continued evaluation is recommended. In the second part of this thesis, the FES-IAB demonstrated to be a valid and reliable instrument to measure activity avoidance due to FoF in Dutch community-dwelling older adults. It can be used in clinical practice to screen for activity restriction or track treatment progress. It may also be used for research into the understudied behavioral consequences of FoF. Overall, the findings in this thesis contribute towards improved management of FoF in older adults.

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Summary

Introduction

Chapter 1 introduced the subject matter and aims of this thesis. The increasing number of older adults in the world is pressuring healthcare systems. To keep healthcare affordable and improve quality of life of older adults, it is essential that disability from health conditions is reduced. One of the major causes of disability in old age are falls. However, the fear of falling (FoF) - also reported as, for example, concerns about falling (CaF) - is even more prevalent. It is associated with a range of negative outcomes, such as activity avoidance, reduced physical functioning and early nursing home admission. Effective interventions for FoF are available, but reach small to moderate effects. This indicates that interventions may still be improved. To optimize interventions, it is important to know which factors influence effects, so that factors with a positive influence can be strengthened and those with a negative influence can be diminished. Effects of interventions can be influenced by their content, but also by other characteristics, such as the setting in which the intervention is offered or the delivery method that is used. Characteristics of the person who receives the intervention can also be important. Part 1 of this thesis explored 1) which overarching characteristics of interventions are effective in reducing FoF in community-dwelling older people, 2) the association between specific intervention components and the reduction of FoF among community-dwelling older people, and 3) whether participant characteristics are moderators of the effects of cognitive behavioral interventions on CaF in community-dwelling older people. Part 2 of the thesis addressed activity avoidance due to FoF. In this part, the psychometric properties of a new instrument for activity avoidance due to CaF were assessed: the Falls Efficacy Scale - International Avoidance Behavior (FES-IAB).

Part 1: Unravelling interventions

In **Chapter 2** of this thesis, the relationship of intervention characteristics with effects of interventions on FoF was explored by conducting a systematic review. Randomized controlled trials (RCTs), conducted in community-dwelling adults aged 65 years or over were included. Data on 50 interventions were systematically extracted and analyzed. The types of interventions and several general characteristics were considered, such as the setting, delivery method,

duration and presence of supervision. With meta-regression, all interventions of a certain type (or: with a certain characteristic) were compared to those not of that type (or: without that characteristic). Holistic exercise interventions, such as Pilates interventions or yoga interventions, were more effective than all other intervention types combined. Most intervention characteristics were not significantly associated with intervention effects, but interventions supervised by a Tai Chi instructor or delivered solely in a community setting were significantly more effective than those that were not. Furthermore, interventions that were tailored, delivered solely at home, or delivered with written materials, were significantly less effective than interventions without these characteristics.

In **Chapter 3**, the review was updated and the content of interventions was examined in more detail. Using a tailor made taxonomy - based on existing taxonomies and consensus discussions - 68 intervention components were identified in 85 interventions. Examples of intervention components are education about fall risk factors, discussion, visualization and assertiveness training. A similar methodology as in Chapter 2 was used and 49 interventions could be included in the meta-regression. We could not analyse the data of the remaining interventions for several reasons. For example, because a measure of variance was not reported and the authors could not be contacted. Most of the components were not associated with intervention effects. However, interventions with holistic exercise, meditation, or body awareness were significantly more effective than interventions without these components. Interventions with self-monitoring or balance exercises were significantly less effective. The identified characteristics and components can be used as inspiration for the optimization of interventions for FoF.

Effects of interventions may also vary according to participant characteristics, i.e. participant characteristics may moderate effects. In **Chapter 4**, we explored whether demographic, health and socio-cognitive participant characteristics moderated effects of two cognitive behavioral interventions; A Matter of Balance – Netherlands (AMB-NL) and A Matter of Balance – Home (AMB-Home). A Matter of Balance is a program that was developed in the United States, especially for older adults who are concerned about falling and avoid activities due to these concerns. AMB-NL and AMB-Home are the group

and individual version, respectively, of this program in the Dutch language. Previous studies have shown that – by using techniques such as restructuring misconceptions, goal setting, home adaptations and physical exercise – the programs can effectively reduce CaF among community-dwelling older people. However, very little is known about participant characteristics that moderate effects of cognitive behavioral interventions on CaF. Moderating effects were investigated by re-analyzing the data of RCTs that evaluated AMB-NL and AMB-Home. Each moderator was initially analyzed separately, but more elaborate models that corrected for multiple moderators at once were also used. The analyses showed that AMB-NL acted as a type of buffer. While poor cognition and increasing levels of symptoms of depression, ADL disability, and feared consequences led to increased levels of CaF in the control group, this was not the case for the intervention group. For AMB-Home, the intervention was more effective in those living with someone else and in those that never fell or fell more than once. For both AMB-NL and AMB-Home, the intervention was effective for those in fair health and not for those in good or poor health. These findings can guide modifications to the recruitment process and intervention material of AMB-NL and AMB-Home.

Part 2: Measuring activity avoidance due to fear of falling

In **Chapter 5**, the psychometric properties of the 16-item FES-IAB and its shortened 7-item version (Short FES-IAB) were assessed. The FES-IAB is a questionnaire about activity avoidance due to CaF that is administered together with a measure of CaF: the Falls Efficacy Scale - International (FES-I). For each item of the FES-I, people answer an additional question about to what extent they avoid activity due to CaF. The possible sum scores of the FES-IAB range from 16 (no avoidance behavior) to 64 (severe avoidance behavior). For the short FES-IAB it ranges from 7 to 28, respectively. A sample of Dutch community-dwelling older adults aged 60 years or over filled out the FES-IAB twice, with one month in between ($n_{wave\ 1}$=744, $n_{wave\ 2}$=686). The FES-IAB demonstrated floor effects; 46.1% of people received the lowest score of 16. Furthermore, the questionnaire was comprehensible to participants, there were very few missing values, and it was quick to administer (median 3.1 minutes). Moreover, the findings indicated adequate construct validity. Correlations with other variables

were close to what was expected, although some of them were slightly less strong than anticipated. FES-IAB scores also differed significantly between groups based on age, sex, fall history, and mental health, as was expected. Furthermore, the FES-IAB was unidimensional. Confirmatory factor analysis with excellent fit indices, demonstrated that a one-factor model fitted the data well. In addition, the questionnaire was internally consistent and test-retest reliability was good, as evidenced by high values of Cronbach's alpha and the intraclass correlation coefficient. The findings were similar for the Short FES-IAB. In short, the FES-IAB and Short FES-IAB demonstrated good feasibility, unidimensionality, structural validity, internal consistency, and test-retest reliability. Floor effects were identified. However, the (Short) FES-IAB seems to be an efficient and valid method to assess avoidance behavior due to CaF and may be valuable to assess the understudied behavioral consequences of CaF in older adults.

Discussion

Chapter 6 shortly discussed the theoretical and methodological considerations for this thesis, like the various conceptualizations of FoF, poor reporting in published literature, explorative approach and difficulties with interpretation of effects. Several recommendations were formulated. First of all, to facilitate future meta-analyses, it is recommended that researchers clearly define the FoF conceptualization which they have chosen and use a measurement instrument that was developed for that specific conceptualization. Second, more research on what constitutes a meaningful change in FoF for older adults is necessary to properly interpret effects of interventions. Third, depending on the individual, FoF may be excessive or can be an appropriate response to an actual physical falls risk. New ways of evaluating interventions that not only consider changes in FoF, but also take into account whether FoF is realistic are required.

Chapter 6 also summarized the main findings. In Part 1 of the thesis, several factors – including intervention components and characteristics of interventions and supervisors – were found to influence effects of interventions on FoF. The findings of this thesis provide input for future studies on interventions for FoF and the development of hypotheses. Hence, it is a first step towards intensifying factors that increase intervention effects on FoF. Furthermore, several participant characteristics were found to moderate the

effects of the existing interventions AMB-NL and AMB-Home. Several suggestions were made for improvement of the interventions, like making efforts to recruit people with symptoms of depression and FoF for AMB-NL, and focusing more on safe behavior for frequent fallers for AMB-home. Poor reporting in the studies that were included in the meta-analyses and the explorative approach used in the thesis, imply that the findings have to be interpreted with caution. If the findings are used to optimize treatments for FoF, evaluation is required to ensure continued effectiveness and to allow for further improvement. In part 2 of the thesis, the psychometric properties of the FES-IAB and Short FES-IAB were found to be adequate. Those working in research and clinical practice may benefit from the application of the (Short) FES-IAB, in order to assess the behavioral consequences of FoF, in addition to FoF and falls. Overall, the findings in this thesis contribute towards improved management of FoF in older adults.

Samenvatting

Inleiding

In **hoofdstuk 1** zijn het onderwerp en de doelen van dit proefschrift geïntroduceerd. Het groeiende aantal ouderen zorgt wereldwijd voor een toenemende druk op de gezondheidszorg. Het is noodzakelijk om de functionele beperkingen die ontstaan door ziekten en aandoeningen te verminderen. Zo blijft de gezondheidszorg betaalbaar en wordt de kwaliteit van leven van ouderen behouden of mogelijk zelfs verbeterd. Een belangrijke en veel voorkomende oorzaak van morbiditeit is vallen. Valangst - ook wel bezorgdheid om te vallen genoemd - komt nóg vaker voor. Valangst is geassocieerd met een aantal negatieve gevolgen, zoals het vermijden van activiteiten, verminderd fysiek functioneren en vervroegde opname in een verpleeghuis. Er zijn verschillende interventies die valangst kunnen verminderen, maar deze bereiken vaak kleine tot matige effecten. Dit voedt de gedachte dat de effecten van interventies wellicht nog geoptimaliseerd kunnen worden. Optimalisatie kan plaatsvinden door factoren die een positieve invloed hebben op de effectiviteit te versterken en factoren die een negatief effect hebben af te zwakken. De effectiviteit van interventies wordt beïnvloed door de inhoud van de interventie en door andere kenmerken. Zo zijn bijvoorbeeld de manier waarop de interventie wordt aangeboden en waar dit wordt gedaan van belang. Kenmerken van de deelnemers aan een interventie kunnen ook belangrijk zijn. Deel 1 van het proefschrift verkent 1) welke overkoepelende interventiekenmerken effectief zijn in het reduceren van valangst bij thuiswonende ouderen, 2) de associatie tussen interventiecomponenten en een afname van valangst bij thuiswonende ouderen, en 3) of kenmerken van deelnemers de effecten van cognitief gedragsmatige interventies op bezorgdheid om te vallen bij thuiswonende ouderen modereren. Deel 2 van het proefschrift behandelt de psychometrische eigenschappen van de Falls Efficacy Scale – International Avoidance Behavior (FES-IAB). De FES-IAB is een instrument voor het meten van vermijdingsgedrag als gevolg van bezorgdheid om te vallen.

Deel 1: Interventies ontrafelen

In **hoofdstuk 2** is met een systematische review en meta-analyse de relatie tussen interventiekenmerken en effecten van interventies op valangst onderzocht. Het onderzoek includeerde gerandomiseerde gecontroleerde

studies uitgevoerd bij ouderen van 65 jaar en ouder. Data van 50 interventies werd systematisch geëxtraheerd en geanalyseerd. In de analyses werden verschillende factoren onderscheiden, onder andere het type interventie en een aantal overkoepelende interventiekenmerken zoals de locatie, hoe lang een interventie duurt, en de aanwezigheid van begeleiding. Met behulp van meta-regressie zijn alle interventies met een bepaalde eigenschap vergeleken met alle interventies zonder die eigenschap. Holistische bewegingsinterventies, zoals Pilates of yoga interventies, waren effectiever dan alle andere typen interventies tezamen. De meeste interventiekenmerken waren niet geassocieerd met de interventie-effecten. Echter waren interventies begeleid door een Tai Chi instructeur of aangeboden in de wijk effectiever dan interventies waarvoor dit niet gold. Verder waren 'getailorde' interventies en interventies die in de thuissituatie of met geschreven materialen werden uitgevoerd minder effectief dan interventies zonder deze kenmerken.

In **hoofdstuk 3** is de systematische review geactualiseerd en de inhoud van interventies in meer detail onderzocht. Er werd een speciale taxonomie voor interventiecomponenten ontwikkeld, gebaseerd op bestaande taxonomieën en consensusdiscussies. Met deze taxonomie zijn in 85 interventies 68 verschillende interventiecomponenten geïdentificeerd. Voorbeelden van interventiecomponenten zijn discussie, visualisatie, assertiviteitstraining en voorlichting over risicofactoren voor vallen. Op 49 van de 85 interventies kon meta-regressie worden toegepast, op een vergelijkbare wijze als in hoofdstuk 2. Voor de overige interventies was de data om diverse redenen niet analyseerbaar, bijvoorbeeld doordat er geen maat van de variantie gerapporteerd werd en er geen contact gelegd kon worden met de onderzoekers. Hoewel de meeste interventiecomponenten niet geassocieerd waren met de interventie-effecten, waren interventies met holistische oefeningen, meditatie en lichaamsbewustzijn significant effectiever dan interventies zonder deze componenten. Interventies met het monitoren van het eigen gedrag, gevoelens en gedachten, en balansoefeningen waren juist minder effectief dan interventies zonder deze componenten. De kenmerken en componenten uit hoofdstuk 2 en 3 kunnen gebruikt worden als inspiratie om effectieve interventies te ontwikkelen of bestaande interventies te optimaliseren.

Effecten van interventies kunnen ook beïnvloed worden door de kenmerken van de deelnemers. Met andere woorden: deelnemerkenmerken kunnen interventie-effecten modereren. In **hoofdstuk 4** werd verkend of demografische, gezondheids- en sociaal-cognitieve kenmerken van deelnemers de effecten van cognitief gedragsmatige interventies modereren. 'A Matter of Balance' is een cognitieve gedragsinterventie die ontwikkeld is in de Verenigde Staten, speciaal voor ouderen die bezorgd zijn om te vallen en activiteiten vermijden vanwege deze bezorgdheid. Zicht op Evenwicht is de Nederlandse versie van 'A Matter of Balance'. De interventie maakt gebruik van technieken zoals het herstructureren van cognitieve misvattingen, doelen stellen, aanpassingen in huis en lichamelijke oefeningen. Zicht op Evenwicht kent twee varianten: een groepscursus en een individuele cursus. Beiden hebben in voorgaande studies laten zien dat bezorgdheid om te vallen bij thuiswonende ouderen vermindert door de cursus, maar er is nog weinig bekend over deelnemerkenmerken die de effecten modereren. Om deze modererende effecten te onderzoeken zijn de onderzoeksdata van de gerandomiseerde gecontroleerde studies van beide cursussen opnieuw geanalyseerd. Elke moderator werd in eerste instantie apart geanalyseerd. Vervolgens werden uitgebreidere modellen getest waarin voor meerdere moderatoren werd gecorrigeerd. De analyses toonden aan dat de groepsvariant als een buffer kan werken. Meer symptomen van depressie, meer beperkingen in activiteiten, meer verwachte gevolgen van vallen en een slechtere cognitie zijn geassocieerd met een toegenomen bezorgdheid in de controlegroep, maar niet in de interventiegroep. De individuele variant was effectiever voor mensen die samenwoonden met anderen, en voor diegenen die nooit of juist vaak vielen. Beide cursussen waren effectiever voor deelnemers met een matige gezondheid. Deze resultaten kunnen gebruikt worden om het wervingsproces en de inhoud van Zicht op Evenwicht aan te passen.

Deel 2: Het meten van vermijdingsgedrag als gevolg van valangst

De FES-IAB is een vragenlijst voor vermijdingsgedrag vanwege bezorgdheid om te vallen, die samen met de Falls Efficacy Scale – International (FES-I) kan worden afgenomen. De FES-I is een vragenlijst voor het in kaart brengen van bezorgdheid om te vallen bij het uitvoeren van activiteiten en bestaat uit 16

vragen. Daarnaast bestaat er ook een verkorte versie van de FES-I die 7 vragen omvat ('Short FES-I'). Voor de FES-IAB en de Short FES-IAB beantwoorden deelnemers voor elke vraag van de FES-I ook een vraag over hoe vaak ze activiteiten vermijden als gevolg van hun bezorgdheid om te vallen. De theoretisch mogelijke somscores voor de FES-IAB bedragen 16 (geen vermijdingsgedrag) en 64 (ernstig vermijdingsgedrag); voor de Short FES-IAB bedragen deze respectievelijk 7 en 28. In **hoofdstuk 5** zijn de psychometrische eigenschappen van de FES-IAB en Short FES-IAB onderzocht. Een steekproef van thuiswonende Nederlandse ouderen van 60 jaar of ouder vulden de FES-IAB twee keer online in. De tweede afname vond een maand na de eerste afname plaats ($n_{afname\ 1}$=744, $n_{afname\ 2}$=686). Er was sprake van een bodemeffect; 46.1% van de deelnemers scoorden de laagst mogelijke waarde van 16. De meeste deelnemers vonden de vragenlijst begrijpelijk. Daarbij waren er weinig missende waarden en was de vragenlijst snel af te nemen (mediaan 3.1 minuten). De constructvaliditeit van de FES-IAB was adequaat: correlaties met andere variabelen lagen in de lijn der verwachting, al waren een aantal van de correlaties iets minder sterk dan voorspeld. Bovendien verschilden de FES-IAB scores zoals verwacht significant tussen groepen gebaseerd op leeftijd, geslacht, valhistorie en mentale gezondheid. Verder werd de FES-IAB ook als unidimensionaal beoordeeld. Uit de confirmatieve factoranalyse bleek uit hoge fitindexen dat een 1-factor model goed bij de data paste. Daarnaast was de vragenlijst intern consistent en had deze een goede test-hertest betrouwbaarheid. Dit bleek uit hoge waarden van Cronbach's alfa en de intraclass correlatiecoëfficiënt. De resultaten waren vergelijkbaar voor de Short FES-IAB. Kortom, zowel de FES-IAB als de Short FES-IAB hadden een goede constructvaliditeit, een unidimensionele structuur, en goede interne consistentie en test-hertest betrouwbaarheid. Bovendien was de vragenlijst eenvoudig af te nemen. Wel was er sprake van een bodemeffect. De (Short) FES-IAB blijkt een valide en betrouwbaar instrument te zijn om vermijdingsgedrag als gevolg van bezorgdheid om te vallen te meten bij de onderzochte populatie. De (Short) FES-IAB kan daarmee waardevol zijn voor het bestuderen van de onderbelichte gedragsmatige gevolgen van valangst bij ouderen.

Discussie

In **hoofdstuk 6** werden een aantal theoretische en methodologische overwegingen besproken, zoals de verschillende conceptualisaties van valangst, ontoereikende rapportage in de wetenschappelijke literatuur ten behoeve van meta-analyses, de exploratieve onderzoeksmethoden en moeilijkheden met de interpretatie van effecten. Op basis van het onderzoek in dit proefschrift kunnen een aantal aanbevelingen geformuleerd worden. Ten eerste wordt aanbevolen dat onderzoekers duidelijk definiëren welke conceptualisering van valangst zij gebruiken en om een meetinstrument te hanteren dat hierop is afgestemd. Dit zal toekomstige meta-analyses faciliteren. Ten tweede is er meer onderzoek nodig naar wat ouderen een belangrijke of betekenisvolle verandering in valangst vinden. Dit kan helpen bij de interpretatie van interventie-effecten. Ten derde zijn er nieuwe manieren nodig om interventies te evalueren. Het hangt af van het individu of valangst buitensporig is of een gepaste reactie op een daadwerkelijk valrisico. Bij het evalueren van interventies dient niet alleen rekening gehouden te worden met gemiddelde veranderingen in valangst, maar ook met of de valangst een realistische inschatting is.

Daarnaast zijn in hoofdstuk 6 de bevindingen kort samengevat. In deel 1 van het proefschrift zijn een aantal factoren naar voren gekomen die de effecten van interventies op valangst beïnvloeden, zoals interventiecomponenten en kenmerken van interventies en begeleiders. De bevindingen kunnen bijdragen aan toekomstige studies over interventies voor valangst en aan het formuleren van hypotheses. Het is dus een eerste stap naar het optimaliseren van de effecten van interventies. Verder zijn een aantal deelnemerkenmerken geïdentificeerd die de effecten van de interventie Zicht op Evenwicht modereren. De interventies zouden op verschillende manieren verbeterd kunnen worden. In de groepsvariant van Zicht op Evenwicht kan bijvoorbeeld meer nadruk gelegd worden op het werven van deelnemers met depressieve symptomen in combinatie met valangst. In de thuisvariant kan bijvoorbeeld meer aandacht besteed worden aan veilig gedrag bij mensen die vaak vallen. Desalniettemin moeten de resultaten van dit proefschrift met enige voorzichtigheid geïnterpreteerd worden, vanwege inadequate rapportage in de studies die zijn ingesloten in de meta-analyses en het exploratieve karakter van de onderzoeksmethoden die zijn gehanteerd. Als interventies geoptimaliseerd

worden aan de hand van de resultaten uit dit proefschrift, is het belangrijk om de interventies te blijven evalueren, zodat de effectiviteit gewaarborgd kan blijven. Uit deel 2 van het proefschrift bleek dat de (Short) FES-IAB adequate psychometrische eigenschappen bezit. Onderzoekers en gezondheidsprofessionals kunnen de (Short) FES-IAB gebruiken om vermijdingsgedrag in kaart te brengen bij thuiswonende ouderen, tezamen met valangst en valhistorie. In het algeheel dragen de bevindingen uit dit proefschrift bij aan een verbeterde behandeling van valangst bij ouderen.

Impact statement

This chapter focusses on the contribution of this thesis to society and science. The thesis consists of two parts and the achieved and potential future impact is described separately for each part below.

Part 1: Unravelling interventions

Society

Fear of falling (FoF) is very common among older adults (Scheffer et al., 2008). It may result in the avoidance of activities during which the risk of falling is perceived as high. If this is the case and the level of fear matches the abilities of an older person, FoF is realistic and protective (Delbaere et al., 2010). However, FoF can also be excessive and can lead to unnecessary avoidance of activities. Other consequences of FoF include physical deterioration, social isolation, and decreased quality of life (Cumming et al., 2000; Delbaere et al., 2004; Meulen et al., 2014). If older adults can no longer independently perform activities due to their FoF, their increased care needs can pressure healthcare systems. Furthermore, due to its association with an increased risk of falls and early nursing home admission (Cumming et al., 2000; Delbaere et al., 2004), FoF is indirectly associated with increased healthcare costs. Therefore, FoF is not only a relevant issue for older adults, but also for society as a whole. Consequently, management of FoF is imperative. When excessive FoF is reduced, older adults may be able to live at home independently for longer and their quality of life may be increased. To achieve this, effective interventions for FoF are required.

An up-to-date overview of interventions was presented in Chapter 2 and 3 of the thesis. The overviews contain information on the type of interventions available (including their characteristics and components), the effectiveness of those interventions (including the size of the effect) and the methodological quality of the studies that evaluated the interventions. The findings were published open access and they are freely available to policy makers and health professionals (Kruisbrink et al., 2021a; Kruisbrink et al., 2021e), whom may find the overview of the interventions helpful. For example, due to the commonness of FoF, policy makers may consider providing financial reimbursements via health insurance for those interventions that also reduce FoF. Alternatively, health professionals may want to address FoF in their clients and may be searching for an existing effective intervention. The thesis can support these

types of decisions, by providing information on what interventions are available, which interventions are effective and how large the expected intervention effects are. Additionally, the provided information on the risk of bias in the studies can help with the interpretation and weighing of the evidence. For example, an intervention that was evaluated in a rigorously conducted study with a low risk of bias may be preferred over an intervention that was evaluated in a study of poor methodological quality.

The thesis also contains details about the characteristics of interventions, such as the setting and delivery method. Furthermore, information about the presence of intervention components, such as strength exercise or education, was included. This overview of intervention characteristics and components is useful in determining if interventions would fit a certain context. For health professionals, this could be the context of an individual client, e.g. the client's preference for an individual intervention. For policy makers, this could be a municipality. For example, municipalities in the Netherlands have a responsibility to support individuals to live at home independently under the social support act (in Dutch: Wet maatschappelijke ondersteuning). If FoF is signaled as a relevant issue for a number of older adults in a municipality, policy makers may be searching for information about group interventions to efficiently target multiple individuals, in order to advise municipalities about what to offer under the social support act. The thesis contains details of several effective interventions that are delivered to groups of older adults in the community, such as a walking exercise program or Tai Chi (Hosseini et al., 2018; Yoo et al., 2010). Conversely, if exercise programs are already offered in the community, cognitive behavioral group interventions could be considered (Parry et al., 2016). The interventions presented in this thesis can be offered as they are. However, the results of this thesis can also be used as input to develop a new intervention or to improve existing interventions. One of the goals of this thesis was to explore which intervention characteristics and components are related to intervention effects. Although it is too early to formulate guidelines and recommendations for practice based on the current results, several characteristics and components were identified that seem to contribute towards intervention effects. These characteristics and

components can serve as inspiration for new interventions or can be incorporated into existing interventions.

Some of the results of the thesis are also directly applicable to current practice. Chapter 4 focused on two interventions that are offered by a number of healthcare organizations in the Netherlands today (Trimbos, n.d.). A Matter of Balance - Netherlands (AMB-NL) and A Matter of Balance - Home (AMB-Home) are the group and individual version of a cognitive behavioral intervention for people with concerns about falling (CaF) and activity avoidance. Both versions have officially been recognized as effective interventions by the Dutch National Institute for Public Health and the Environment and they are covered by several health insurance companies (Afdeling gezond leven, 2020; VeiligheidNL, 2021). By analyzing the data of the effectiveness trials of AMB-NL and AMB-Home, several participant characteristics were found to influence the effects of the interventions. For example, AMB-NL is more effective for people with depressive symptoms or lower levels of cognition. In addition, AMB-Home was more effective in those living together with someone else. These findings can be used to work towards more inclusive recruitment. Additionally, adaptations can be made to the interventions. For example, more intervention specific support can be offered to those participants of AMB-Home that live alone by reminding participants of their personal goals and planned activities in between sessions. These findings can contribute to continued improvement of AMB-NL and AMB-Home.

Science

Scientific impact was generated in four ways. First of all, the results were spread through the scientific community through several channels. At the time of publication of this thesis, two of the three articles of Part 1 were published in open access journals (Kruisbrink et al., 2021a; Kruisbrink et al., 2021e). This means the results are freely available for all, and can inform researchers. The findings were also presented at several scientific conferences. Furthermore, most of the data and all of the syntaxes underlying the findings were made openly available in an online database (Kruisbrink et al., 2021b; Kruisbrink et al., 2020; Kruisbrink et al., 2021f). Other researchers can use the data to validate findings or they can adapt and build upon the work of this thesis in future

studies. Second, although much of the work in this thesis was explorative and needs further confirmation and validation, a few characteristics and components seem to be associated with improved or decreased intervention effects on FoF. These findings can be used to generate hypotheses for future studies and for the development of conceptual models of interventions for FoF. Third, a start was made with a taxonomy, with which the content of interventions for FoF can be identified and categorized. The Prevention of Falls Network Europe (ProFaNE) already developed and published a fall prevention taxonomy. However, their taxonomy was not specifically developed for interventions with FoF as an outcome, and some components that are relevant were not included, such as meditation. Furthermore, because the ProFane taxonomy aimed to balance between a detailed and simple approach, it categorizes some interventions on the level of intervention types, such as cognitive behavioral interventions. This ignores that these interventions contain components such as cognitive restructuring and problem solving. The taxonomy presented in Chapter 3 was tailor made and presents the highest level of detail that could be achieved for interventions with FoF as an outcome. Fourth, the thesis illustrates an innovative approach to a complex issue, namely unravelling interventions and pinpointing what contributes to their effects. We were able to peek into the black box of interventions, by investigating interventions from multiple perspectives and on different levels of detail. On a meta-level, we examined what factors may be associated with intervention effects. Although meta-analysis has been around for some time, using meta-regression to investigate intervention characteristics and components is relatively new and it had never been attempted before for FoF. On a more detailed level, we examined how participants of interventions may influence effects. Considering that we used only published data and secondary data analysis, valuable information could be collected with relatively little effort and costs. It is likely that such an approach can be applied much more often, also in other areas, for interventions that reach small or moderate effects on other outcomes.

Part 2: Measuring activity avoidance due to fear of falling

Society

Many older adults avoid activities due to FoF (Halfens et al., 2016; Zijlstra et al., 2007). This avoidance behavior can be protective, but excessive avoidance of activities due to FoF may lead to an unnecessary decline in physical function, disability in the performance of activities and more falls (Delbaere et al., 2004; Deshpande et al., 2008). Therefore, it is important to screen for activity avoidance due to FoF in older adults that have a fall history or FoF. A few instruments that measure activity avoidance due to FoF are available (Lachman et al., 1998; Landers et al., 2011; Yardley & Smith, 2002), but their administration takes a substantial amount of time, causes additional burden, and is not yet routine practice. In this thesis, the Falls Efficacy Scale – International Avoidance Behavior (FES-IAB) was evaluated (Chapter 5). The FES-IAB is an instrument for activity avoidance due to CaF. It adds questions to an already commonly used measure for CaF; the Falls Efficacy Scale – International (FES-I) (Yardley et al., 2005). For each item of the FES-I, people are also asked to what extent they avoid activities due to their CaF. The FES-IAB was valid and reliable in a Dutch sample of community-dwelling older adults. Because it measures activity avoidance together with an existing measure for CaF, the FES-IAB is relatively quick and easy to administer. A valid and reliable shorter version, the Short FES-IAB, is also available when the setting requires it or time is limited. Clinical practice may benefit from using the FES-IAB to screen for activity restriction, set goals or track treatment progress. This is helpful to improve support of older adults with CaF.

Science

So far, there has been little attention for the behavioral consequences of falls and FoF in research. Avoiding activities is one important behavioral consequence. Available studies demonstrate that it is very common among older adults and that it is associated with negative outcomes. Activity avoidance due to FoF has implications for the independence of older adults and represents an important outcome to assess. Yet, few studies actually take it into account and there is not yet one widely used measurement instrument for this outcome.

The FES-IAB was first introduced by Dorresteijn and colleagues in 2011 (Dorresteijn et al., 2011) and the psychometric properties of the FES-IAB were still unknown. In 2013, the FES-IAB was administered online to a sample of older adults of the Longitudinal Internet studies for the Social Sciences (LISS) panel(CentERdata, 2014). In Chapter 5 of this thesis, the data of the LISS panel was used to evaluate the psychometric properties of the FES-IAB. Although the questionnaire demonstrated floor effects, the instrument was otherwise valid and reliable. These results are encouraging. After further validation and translation, the FES-IAB can be a valuable addition to the research field of fall prevention. Because it can be administered together with the FES-I, it may be more efficient and less burdensome for research participants than other measures of activity avoidance due to FoF. Hence, it has the potential to become a routine measure in clinical trials, which would facilitate research into the understudied behavioral consequences of FoF and would improve comparability of studies. In the future, the FES-IAB may be considered to be added to a common outcome set for studies in the field of falls and FoF. Assessing falls, FoF and activity avoidance as a set allows for better insight into the effects of interventions. For example, if all three of these outcomes are administered, it can be assessed whether interventions cause a realistic level of FoF, with levels of activity avoidance that match the capabilities of the older adult and without increasing adverse fall events.

The article describing the evaluation of the FES-IAB has been published open access and is freely available (Kruisbrink et al., 2021c). The data that underlies this part of the thesis is already available upon request from the LISS panel (CentERdata, 2014). The syntax and a Dutch and English version of the questionnaire will be made openly available online (Kruisbrink et al., 2021d).

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About the author

Marlot Kruisbrink grew up in North-Brabant (the Netherlands), where she attended primary and secondary school. In 2011, she started the study Nutrition and Health at Wageningen University. She obtained her bachelor's degree in 2014 and continued with a master's degree in Nutrition and Health, with a specialization in Epidemiology and Public Health. Her master thesis concerned the evaluation of an E-health tool for home assisted older people. In 2016, she conducted an internship at Warwick University on the subject of blood lipids and sleep and obtained her master's degree.

Between 2017 and 2021, Marlot worked as a PhD candidate at Maastricht University (department of Health Services Research). As part of her PhD program, she tutored and supervised several bachelor students. Currently, Marlot works as a lecturer for the Graduate School training program, where she teaches PhD students on subjects such as scientific integrity, open science and science communication. Marlot also works as a researcher at Maastricht University (department of Health Services Research) on the further development of the TIP-toolbox.

Scientific publications

Publications

Kruisbrink, M., Crutzen, R., Kempen, G.I.J.M., Zijlstra, G.A.R. (2021). Assessing avoidance behavior due to concerns about falling: Psychometric properties of the FES-IAB in a sample of older adults of an online panel. *Archives of Gerontology and Geriatrics*, *97*, 104469. https://doi.org/10.1016/j.archger.2021.104469

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Miller, M. A., Kruisbrink, M., Wallace, J., Ji, C., Cappuccio, F. P. (2018). Sleep Duration and Incidence of Obesity in Infants, Children and Adolescents: A Systematic Review and Meta-Analysis of Prospective Studies. *Sleep, 41*(4), zsy018. https://doi.org/10.1093/sleep/zsy018

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Conference contributions

Kruisbrink, M., Crutzen, R., Kempen G.I.J.M., Ambergen, T., Zijlstra G.A.R. (2021). *Intervention components that contribute to a reduction in fear of falling in old age: a systematic review and meta-analysis* [Online oral presentation]. Virtual NKG25 Nordic Gerontology Congress, June 2-4 2021

Kruisbrink, M., Delbaere, K., Kempen, G.I.J.M., Crutzen, R., & Rixt Zijlstra, G.A.R. (2019). *Program characteristics associated with reduced fear of falling: a*

systematic review and meta-analysis of RCTs [Oral presentation]. The Gerontological Society of America 71st Annual Scientific Meeting, November 13-17 2019, Austin, Texas, USA. S19. Published in *Innovation in Aging*, *3*(Suppl 1). https://doi.org/10.1093/geroni/igz038.070

Kruisbrink, M., Delbaere K., Crutzen, R., Ambergen, A.W., Kempen, G.I.J.M., Zijlstra, G.A.R. (2019). Het ontrafelen van effectieve interventiekenmerken voor het verminderen van valangst bij thuiswonende ouderen: een systematische review en meta-analyse [Oral presentation]. 15e Nationaal Gerontologiecongres, November 1 2019, Ede, the Netherlands. S7.3. Published in *Tijdschrift voor Gerontologie en Geriatrie*. Oct 30;50(3). https://doi.org/10.36613/tgg.1875-6832/2019.03.03

Kruisbrink, M., Delbaere, K., Kempen, G.I.J.M., Crutzen, R., Cheung, K.L., Kendrick, D., Iliffe, S., Zijlstra, G.A.R. (2019) *Unravelling the Characteristics of Interventions That Contribute to a Reduction in Fear of Falling among Community-Dwelling Older People: A Systematic Review* [Oral presentation and poster presentation]. International Association of Gerontology and Geriatrics (IAGG) European Region Congress, May 23-25 2019, Gothenburg, Sweden. https://iagger2019.se/program/scientific-program/

Kruisbrink M., Delbaere K., Kempen G.I.J.M., Crutzen R., Cheung K.L., Kendrick D., Iliffe S., Zijlstra G.A.R. (2018). *Which characteristics of interventions contribute to a reduction in fear of falling? A systematic review* [Poster presentation]. CAPHRI research day 2018, November 6, Valkenburg, the Netherlands.

Kruisbrink M., Delbaere K., Kempen G.I.J.M., Crutzen R., Cheung K.L., Kendrick D., Iliffe S., Zijlstra G.A.R. (2018). *Characteristics of interventions associated with a change in fear of falling among community-living older people. A systematic review and meta-analysis of RCTs* [Poster presentation]. 17th European Doctoral Conference in Nursing Science, June 22-23 2018, Maastricht, the Netherlands.

Living lab in ageing and long-term care

Living Lab in Ageing and Long-Term Care

This thesis is part of the Living Lab in Ageing and Long-Term Care, a formal and structural multidisciplinary network consisting of Maastricht University, nine long-term care organizations (MeanderGroep Zuid-Limburg, Sevagram, Envida, Cicero Zorggroep, Zuyderland, Vivantes, De Zorggroep, Land van Horne & Proteion), Intermediate Vocational Training Institutes Gilde and VISTA college and Zuyd University of Applied Sciences, all located in the southern part of the Netherlands. In the Living Lab we aim to improve quality of care and life for older people and quality of work for staff employed in long-term care via a structural multidisciplinary collaboration between research, policy, education and practice. Practitioners (such as nurses, physicians, psychologists, physio- and occupational therapists), work together with managers, researchers, students, teachers and older people themselves to develop and test innovations in long-term care.

Academische Werkplaats Ouderenzorg Limburg

Dit proefschrift is onderdeel van de Academische Werkplaats Ouderenzorg Limburg, een structureel, multidisciplinair samenwerkingsverband tussen de Universiteit Maastricht, negen zorgorganisaties (MeanderGroep Zuid-Limburg, Sevagram, Envida, Cicero Zorggroep, Zuyderland, Vivantes, De Zorggroep, Land van Horne & Proteion), Gilde Zorgcollege, VISTA college en Zuyd Hogeschool. In de werkplaats draait het om het verbeteren van de kwaliteit van leven en zorg voor ouderen en de kwaliteit van werk voor iedereen die in de ouderenzorg werkt. Zorgverleners (zoals verpleegkundigen, verzorgenden, artsen, psychologen, fysio- en ergotherapeuten), beleidsmakers, onderzoekers, studenten en ouderen zelf wisselen kennis en ervaring uit. Daarnaast evalueren we vernieuwingen in de dagelijkse zorg. Praktijk, beleid, onderzoek en onderwijs gaan hierbij hand in hand.

PhD-theses living lab in ageing and long-term care

Marlot Kruisbrink. Towards enhanced management of fear of falling in older people: Unravelling interventions and measuring related avoidance of activity. 2022

Ruth Vogel. Nurses in the Lead: empowering community nurse leaders to implement evidence into practice. 2022

Fabian Groven. The bed bath with or without water? It's a wash! Experiences with the washing without water intervention used for the bed bath. 2021

Roy Haex. Take a look through my eyes: The development of an experienced quality measure with clients, informal, and formal caregivers in Dutch home care. 2021

Sascha Bolt. The fundamentals of a DEDICATED palliative approach to care for people with dementia. 2021

Angela Mengelers. To risk or to restrain? Involuntary treatment use in people with dementia living at home. 2021

Katya Sion. Connecting Conversations. Experienced quality of care from the resident's perspective: a narrative method for nursing homes. 2021

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Donja Mijnarends. Sarcopenia: a rising geriatric giant. Health and economic outcomes of community-dwelling older adults with sarcopenia. 2016

Tanja Dorresteijn. A home-based program to manage concerns about falls. Feasibility,

effects and costs of a cognitive behavioral approach in community-dwelling, frail older people. 2016

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Sandra Zwakhalen. Pain assessment in nursing home residents with dementia. 2007