Are multifactorial interventions effective in reducing falls in community-dwelling older adults? A systematic review and meta-analysis.

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Introduction

Globally, the population of those aged >60 years is set to double from 11% of the total population to 22% between 2000 and 2050, an increase from 605 million to two billion people (World Health Organisation 2014). By 2020, the proportion of the global population aged ≥65 will exceed the number of children aged <5 years for the first time in recorded history (United Nations 2017). In Ireland, the Central Statistics Office (CSO) predict that Ireland's older adult population (adults aged ≥65 years) will grow from 637,567 in 2016 to circa 1.4 million by 2041 (Central Statistics Office 2013, p.33; Central Statistics Office 2017, p.20). With the anticipated growth in the older adult population on a national and international level over the next three decades, the demand for health services will unquestionably increase (Central Statistics Office 2017, p.65).

In the older adult population, falls are one of the primary causes of disability, which includes reduced function, poorer quality of life and higher mortality rates (Jin *et al.* 2015). One third of older adults fall annually, with the frequency of falls increasing with age and frailty levels (World Health Organisation 2007, p.1; Health Service Executive 2008, p.2). Frailty can be described as an age-related decline in physiological structures that increases an individual's vulnerability and likelihood of experiencing adverse outcomes such as falls or hospitalisation (Clegg *et al.* 2013). Of the one in three older adults that fall annually, two thirds of these will fall again in the following six-month period (Gazibara *et al.* 2017).

In older adults, falls are considered the seventh most burdensome disorder, as defined by disability adjusted life years (DALY's) (Prince *et al.* 2015). DALY's are a measure of health loss, how many 'healthy' years are lapsed due to impairment and are calculated by adding the numbers of years lived with disability and the number of years lost because of premature mortality (Murray *et al.* 2012). Post-fall, fallers can have decreased independence, a loss of autonomy and decreased mobility levels, all of which further impact an individual's capacity to complete their activities of daily living (World Health Organisation 2007). Financially, the cost of falls can vary dependent on the severity of the fall. The cost can be up to $11,000 per fall, contributing up to 1.5% of total healthcare costs within Australia, the United States and the European Union (Heinrich *et al.* 2010).

Currently, the UK quality standard provided by the National Institute for Health and Care Excellence (NICE) recommends that older adults at risk of falling are provided with a multifactorial assessment and individualised treatment intervention (National Institute for

Health and Care Excellence 2013). The World Health Organisation (WHO) global report on falls prevention also recommends the use of multifactorial assessment and subsequent appropriate interventions (World Health Organisation 2007). Similarly, the guidelines produced by the American Geriatrics Society(AGS)/British Geriatrics Society(BGS) advocate for a multifactorial intervention for falls prevention (Kenny *et al.* 2011). Multifactorial interventions aim to target the multiple risk factors that may increase an older adult's risk of falling (Karlsson *et al.* 2013). Risk factors may be modifiable (e.g. decreased balance) or non-modifiable (e.g. age) (Tuunainen *et al.* 2014). Falls usually have more than one contributing factor, so therefore in targeting those specific to an individual, theoretically the greatest benefits can be seen (Karlsson *et al.* 2013; Scheffer *et al.* 2013).

Pohl *et al.* (2014) carried out a prospective cohort study focused on community-dwelling older adults aged ≥ 75 years (n = 230). Over a five-year period, the authors found that participants who self-reported a history of an injurious fall were at a significantly higher risk of falls recurring compared to those who reported no falls history (hazard ratio 2.78, 95% CI 1.40-5.50). An injurious fall was defined as a fall *'severe enough to cause a visit to an Emergency Department.'* Multifactorial interventions were recommended by the authors to prevent the occurrence of further falls in those with a falls history. Other risk factors for falling reported in the literature include intrinsic factors such as co-morbidities and visual impairment and extrinsic factors such as environmental factors including poor lighting and footwear (Tuunainen *et al.* 2014).

Falls prevention approaches can vary from single to multiple mechanisms, with mixed evidence supporting their effectiveness (Day 2013). Over the past decade, much research has been carried out focusing on falls prevention in older adults, including using multifactorial interventions. These interventions have varying components including making modifications to the home environment, medication reviews and graded exercise. Research in the area of multifactorial interventions is inconsistent in terms of the specifics of the intervention provided (de Vries *et al.* 2010). While the guidelines mentioned previously all advocate for a multifactorial intervention as the primary method in reducing the number of falls in older adults, only the HSE report from 2008 provides precise details on the type of assessment to be carried out and intervention(s) to be provided at different time points (Health Service Executive 2008, p.2).

A recent pilot study carried out by Bruce *et al.* (2017) included a multifactorial intervention based specifically on the guidelines provided by the AGS/BGS and NICE. The falls risk factor assessment looked at seven risk factors (red flags, gait & balance, postural hypotension, medication review, feet & footwear, vision and environmental hazards) as well as falls history. Treatment was then provided based on assessment results, with protocols in place for each risk factor. In this pilot study of 148 community-dwelling participants, the multifactorial intervention was found to be suitable and acceptable for participants and primary care staff. While positive outcomes were noted in terms of number of fallers, it must be noted that this was only a pilot study with a relatively small sample size.

While there is research supporting the guidelines in using multifactorial interventions, there is some opposing research. A randomised control trial (RCT) carried out by Russell *et al.* (2010) compared usual care with a multifactorial falls prevention programme in older adults with a falls history. The intervention provided was individualised to each participant based on their baseline assessment, and followed guidelines set by the authors. No statistically significant difference was found after a 12-month follow-up in the number of fallers in the intervention group (50.9%) compared to the control group (45.8%). The authors reported poor levels of co-ordination among the services provided, with interventions commencing two-four months post-fall. The timing and quality of falls prevention interventions were issues raised by healthcare professionals in qualitative research (Ploeg *et al.* 2017).

A further RCT with a similar intervention provided to older adults deemed to be a falls risk found no significant decrease in the falls rate in the intervention group (51.9%) compared to usual care (55.9%) over 12 months (de Vries *et al.* 2010). While there was some reduction noted regarding falls risk factors (physical performance), the authors expressed that due to the variability in the components of multifactorial interventions, it is difficult to ascertain which aspects are and are not effective in addressing risk factors.

Gates *et al.* (2008) previously reviewed the literature on multifactorial interventions for falls prevention in community-dwelling older adults in an emergency-care setting. In the 19 included studies, there was no beneficial effect at 12-month follow-up for multifactorial interventions in falls prevention. Insufficient evidence was provided on the rate of falls and injuries. The authors noted that more research was needed, and the evidence base available at the time was of poor quality.

More recently, a Cochrane review of 19 trials (n= 9503) carried out in 2012, investigated interventions used for falls prevention, including multifactorial interventions (Gillespie *et al.* 2012). Similar to Gates *et al.* (2008) the authors found that while multifactorial interventions in community-dwelling older adults can reduce the falls rates (Rate Ratio 0.76, 95% CI 0.67 to 0.86), there is no effect on the number falling during follow-up. The interventions provided were diverse in their components, again making it difficult to directly compare the included studies.

As can be seen from the literature discussed, there is conflicting evidence regarding the use of multifactorial interventions as a falls prevention method. Despite all major guidelines recommending its' use as a method for falls prevention, some research would question its' effectiveness of in falls prevention. To the extent of the authors knowledge, the totality of evidence regarding the effectiveness of multifactorial interventions in reducing falls in community-dwelling older adults has not been explored independently since done so by Gates *et al.* (2008) or as a component of falls prevention since Gillespie *et al.* (2012). Consequently, the aim of this paper is to systematically review the totality of evidence exploring the effectiveness of multifactorial interventions in reducing falls in community-dwelling older adults, and if suitable, perform a meta-analysis.

The objectives of this systematic review are as follows:

- To explore the totality of evidence relating to the effectiveness of multifactorial interventions in reducing the falls rate in community-dwelling older adults
- To synthesis the evidence regarding effectiveness of multifactorial interventions in improving community-dwelling older adults' impairments, activity limitations and participation restrictions

This systematic review will follow the guidelines from the 'Disability and Rehabilitation' Journal (Taylor and Francis 2017).

Methods

Study Design

A systematic review of RCT's and cluster RCT's was carried out. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed (Moher *et al.* 2009). The Cochrane Handbook for Systematic Review of Interventions was used as a guide (Higgins and Green 2011).

Study Identification

The following online electronic databases were searched for possible studies in October 2017: Cochrane, Web of Science, Scopus, PubMed, CINAHL, MEDLINE. The search strategy involved three main sections: 1. Older adults, 2. Multifactorial intervention, 3. Falls. The full search strategy employed across the various databases can be seen in Appendix 1. Searches were limited in each database by title and/or abstract as available.

The inclusion criteria used was as follows:

- Population – community-dwelling older adults aged ≥65 years
- Intervention – multifactorial intervention defined as *"an intervention with multiple components that aims to address the risk factors for falling that are identified in a person's individual multifactorial assessment,"* (National Institute for Health Care and Excellence 2017)
- Control – usual care or another intervention that is not multifactorial
- Outcome – falls rate and impairments (e.g. strength) and/or activity limitations (e.g. mobility) and/or participation restrictions (e.g. socialising)

Study Selection

Results from all databases were placed in the Endnote database. Duplicates were removed by Endnote and any remaining duplicates were removed manually by the author. Identified studies were then screened against the inclusion criteria by title and abstract by the author in Endnote. Four groups were created: 1. Relevant papers – studies that met the inclusion criteria, 2. Irrelevant papers – studies that did not meet the inclusion criteria, 3. Discussion – studies not meeting the inclusion criteria but were of interest to the author, 4. Unsure papers – studies that

were not clear from their abstract if they met the inclusion criteria or not. Studies were placed into the applicable group. Once this was complete, the unsure and relevant groups were screened against the inclusion criteria. Full texts of the studies were then sourced and reviewed by the author. Once the final number of included studies was collated, the reference lists of these were searched by title.

Qualitative Appraisal & Study Synthesis

The Cochrane Risk of Bias Tool was used to quality assess the included studies (Higgins *et al.* 2011). Studies were assessed under the domains of selection bias, performance bias, attrition bias, detection bias, reporting bias and other sources of bias. Each domain was deemed to be high, low or unclear risk of bias. From this the overall risk of bias was determined. Descriptive data – the authors, year, country, study population, the intervention(s), the control and the outcomes measured was compiled into a table in Microsoft Excel. Quantitative data from all outcomes measured in all studies was gathered into a final table in Microsoft Excel. In the case where data was missing, the authors were contacted.

For continuous data, the mean and standard deviation (SD) data of all outcomes measured post-intervention for intervention and control groups was collected. If the mean and SD were not available, the median and interquartile range (IQR) data was used. If neither of these were available, the change score was used. For dichotomous data, the odds ratio/relative risk and 95% confidence interval (CI) was gathered. For continuous and dichotomous data, the number of participants in the intervention and control groups for all outcomes in all studies was collected. A Microsoft Excel file was created in which studies were grouped under outcomes that were shared between two or more studies. All Microsoft Excel files were shared with the second author who reviewed the data. Both authors met to discuss the data collected and decide what data would be used for the meta-analysis.

Statistical Analysis

To perform the statistical analysis, the Cochrane Review Manager 5 software was used (The Cochrane Collaboration 2014). In studies that assessed the same outcome but used contrasting scales (e.g. SF-36 and the Frenchay Activities Index measuring activity limitation), the treatment effect was determined using the standardised mean difference (SMD) and 95% CI. In studies that assessed the same outcome using the same scales, the mean difference (MD) and 95% CI was used.

In analysing the primary outcome of falls rate, and secondary outcomes of impairments, activity limitations and participation restrictions, continuous data only was used and evaluated as continuous variables. The dichotomous data (e.g. number of injurious falls and the number of falls) collected was not analysed due to the lack of dichotomous data that was available from the studies. If attempts to contact authors for further data were ineffective, the studies in question were not included in the analyses of those specific outcomes. If the authors reported the median and IQR results rather than the mean and SD, the median was used as a substitution for the mean (Hozo *et al.* 2005). For the SD, the IQR was multiplied by 0.75 as a substitute (Hozo *et al.* 2005).

The I^2 statistic was used to establish heterogeneity, with considerable heterogeneity treated as I^2>50%. A fixed-effect model was used when I^2 was less than or equal to 50%. When I^2 was greater than 50%, separate study characteristics were examined to recognise possible sources of heterogeneity, utilising pre-prepared subgroup analyses. If heterogeneity was deemed substantial, both the fixed-effect model and the random-effects model were used. This allowed assessment of the sensitivity for the selection of the model style. The most conservative result was used when dissimilar outcomes were obtained. No additional quantitative analysis (subgroup/sensitivity) was carried out.

Results

From the initial 3,365 studies identified, ten studies were suitable to be included in the narrative synthesis, with nine of these used in the meta-analysis. The PRISMA flow diagram in summarises the study screening and selection process, see Appendix 2.

The characteristics of the included studies are outlined in Appendix 3. Nine of the included studies were RCT's (van Haastregt *et al.* 2000; Day *et al.* 2002; Clemson *et al.* 2004; Lord *et al.* 2005; Shumway-Cook *et al.* 2007; Hendriks *et al.* 2008; Markle-Reid *et al.* 2010; Fairhall *et al.* 2014; Mikolaizak *et al.* 2017) with one being a cluster RCT (Tinetti *et al.* 1994). Inclusion criteria for this review was older adults aged ≥65 years, however all except for three studies had a population aged ≥70 years (Shumway-Cook *et al.* 2007; Hendriks *et al.* 2008; Mikolaizak *et al.* 2017).

Day *et al.* (2002) and Shumway-Cook *et al.* (2007) were the only studies to not have their population including individuals deemed at risk of falling (predominantly determined by having a history of falls, having a fear of falling (FOF) and/or feeling at risk of falling), having a history of fall(s) or classified as 'frail.' Frailty was most commonly determined by the Sickness Impact Profile or according to the Cardiovascular Health Study criteria. Interventions and follow-up varied in length from six months (Markle-Reid *et al.* 2010) to 18 months (van Haastregt *et al.* 2000; Day *et al.* 2002).

All interventions provided were individualised to each participant's needs based on a baseline assessment. The role of the multi-disciplinary team in providing the intervention was described in detail in the interventions presented by four authors (Clemson *et al.* 2004; Hendriks *et al.* 2008; Markle-Reid *et al.* 2010; Fairhall *et al.* 2014). One study, Shumway-Cook *et al.* (2007), used group classes as a component of their intervention.

Follow-up post-intervention was provided by two studies (Tinetti *et al.* 1994; Clemson *et al.* 2004). Control groups primarily received usual care (van Haastregt *et al.* 2000; Shumway-Cook *et al.* 2007; Hendriks *et al.* 2008; Markle-Reid *et al.* 2010; Fairhall *et al.* 2014). Usual care was poorly described across the included studies. Two studies provided social visits by student therapists as the control (Tinetti *et al.* 1994; Clemson *et al.* 2004). All studies included a falls outcome, with secondary outcomes including mobility, mental health and social participation.

Methodological Quality

Study quality was assessed using the Cochrane Risk of Bias Tool (Higgins *et al.* 2011). Methodological quality under the various domains of the tool for each study can be seen in Appendix 4. Overall study quality varied from low to unclear quality, most having an unclear risk of bias. Performance bias across all studies varied from unclear to high risk of biases, due to a lack of detail provided by authors in their methods. Conversely, attrition bias and selection bias ranged from low to unclear biases, due to more detailed reporting by all authors.

Primary Outcome

The primary outcome was falls rate. While all included studies reported a falls rate outcome, only three studies reported falls rate as continuous data (Shumway-Cook *et al.* 2007; Markle-Reid *et al.* 2010; Mikolaizak *et al.* 2017). Therefore, only data from these three studies was included in this part of the meta-analysis. There was no statistically significant effect for falls rate between the intervention (n = 392) and control groups (n= 391), (REM, MD=0.18, 95%CI -0.79 to 1.16, I^2=88%, P=0.71), see figure 1.

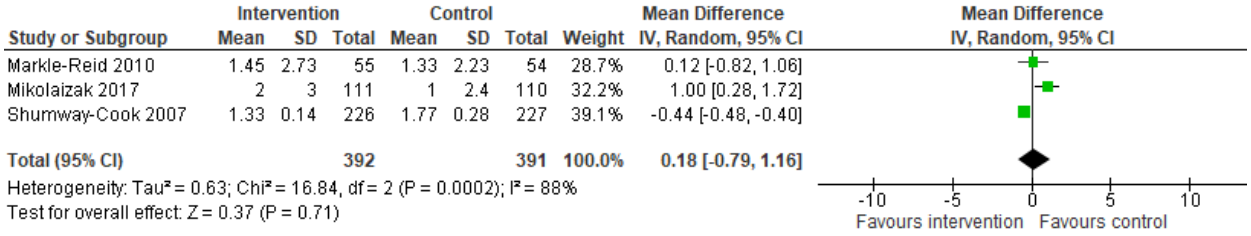

Figure 1: Forest plot for falls rate

Secondary Outcomes

Secondary outcomes included impairments, activity limitations and participation restrictions.

Impairments

Data was collected for strength (knee extension), but no statistically significant effects were found favouring multifactorial interventions, see Appendix 5 (figure 5). Studies reporting balance outcomes were too heterogenous to carry out a meta-analysis, due to a mix of proactive (e.g. TUG) and reactive (e.g. postural sway) measures reported.

Activity Limitations

Data was collected for activity limitation and mobility. Statistically significant effects favouring multifactorial interventions were seen for activity limitation between the intervention (n = 537) and control groups (n = 531) (REM, MD=1.53, 95%CI 0.50 to 2.56, I^2=0%, P 0.003), see figure 2. Data from an activity limitation outcome measure was pooled from four studies (van Haastregt et al. 2000; Clemson et al. 2004; Hendriks et al. 2008; Markle-Reid et al. 2010). No statistically significant effects favouring multifactorial interventions were seen in mobility, see Appendix 5 (figure 6).

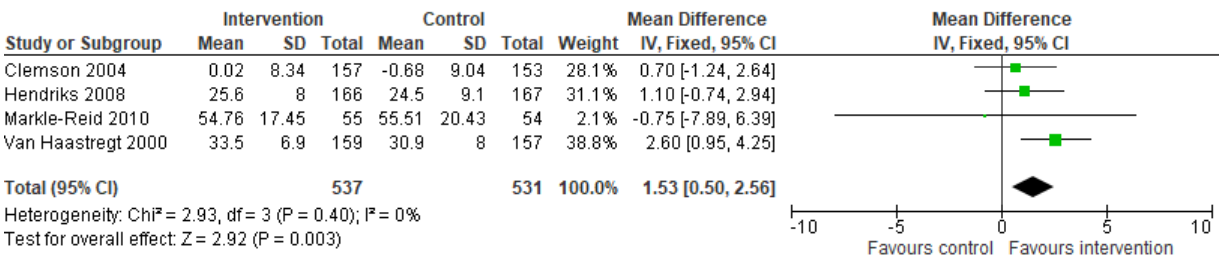

Figure 2: Forest plot for activity limitation

Participation Restrictions

Data was collected for social participation, mental health, FOF and falls risk. Statistically significant effects favouring multifactorial interventions were seen for falls risk between the intervention (n = 273) and control groups (n = 269), (REM, MD=-0.37, 95%CI -0.64 to -0.10, I^2=35%, P=0.007), see figure 3. Two studies reported falls risk (Tinetti *et al.* 1994; Fairhall *et al.* 2014). No statistically significant effects favouring multifactorial interventions were seen in terms of social participation, mental health or FOF, see Appendix 5 (figures 7,8,9).

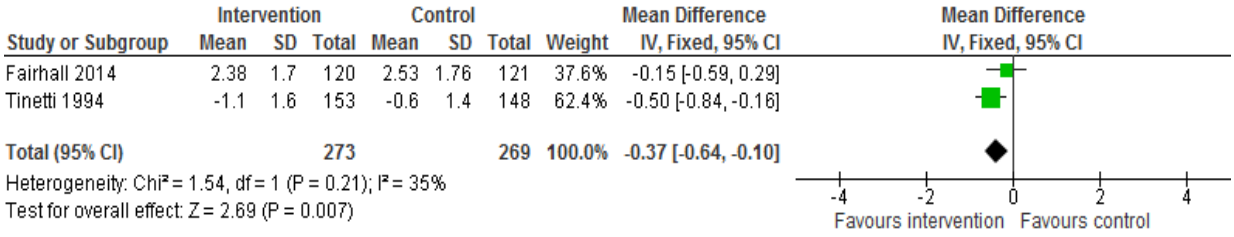

Figure 3: Forest plot for falls risk

Discussion

Statement of key findings

This systematic review evaluated the totality of evidence with respect to multifactorial interventions in falls prevention across a wide variety of countries. There was a statistically significant effect of multifactorial interventions found in activity limitation and falls risk in community-dwelling older adults. No statistically significant effects favouring multifactorial interventions were established in the falls rate, strength (knee extension), mobility, social participation, mental health or FOF in community-dwelling older adults.

Results in the context of the current literature

Gillespie *et al.* (2012) previously reviewed the literature with regards to interventions for falls prevention in community-dwelling older adults. The authors reviewed the effect of over 20 interventions in preventing falls, including exercise, medication provision/withdrawal and multifactorial interventions. In comparing the effect of multifactorial intervention in reducing the falls rate, the authors carried out a meta-analysis of 19 trials. When compared to this systematic review, the authors had broader inclusion criteria. Gillespie *et al.* (2012) additionally included trials in which participants were recruited from a hospital setting, while this review only focused on older adults that were community-dwelling. Gillespie *et al.* (2012) included quasi-RCT's in their review as well as mixed population studies (e.g. older adults that were community-dwelling and those that required higher dependency places of residence in the same RCT), while this review excluded these.

Contrary to this systematic review and meta-analysis, Gillespie *et al.* (2012) found that there was a statistically significant effect favouring multifactorial interventions versus control with regards to falls rate, but not for falls risk. However, Gillespie *et al.* (2012) found that multifactorial interventions had no effect on the falls rate at various follow-up times. The varying results between this systematic review and that carried out by Gillespie *et al.* (2012) could be due to multiple factors. As mentioned, the inclusion criteria outlined in both reviews were varied, leading to more studies being included by Gillespie *et al.* (2012). While Gillespie

et al. (2012) may have encompassed more trials in their meta-analysis, the relevance of their results to community-dwelling older adults cannot be certain due to their high levels of population heterogeneity within studies. Although this meta-analysis for falls rate only involved data from three studies, all three studies had a similar population demographic.

All except two studies included in this review; Day *et al.* (2002) and Shumway-Cook *et al.* (2007), had a population classified as a falls risk. Of the remaining studies, there were high levels of heterogeneity as to how participants were deemed to be a falls risk. Tinetti *et al.* (1994) identified seven risk factors for falls to determine an individual's falls risk. However, as Deandrea *et al.* (2010) established, risk factors can have socioeconomic, medical and psychological components. Consequently, using methods such as those used by Tinetti *et al.* (1994) to identify those deemed a falls risk may not be the most comprehensive measure.

Excellent reliability and validity for the Falls Efficacy Scale-International (FES-I) and the Short Falls Efficacy Scale-International (Short FES-I) has been established in assessing FOF in community-dwelling older adults (Yardley *et al.* 2005; Kempen *et al.* 2008; Delbaere *et al.* 2010). FOF has been shown to be indicative of a higher falls risk in community-dwelling older adults (Yumi and Yukari 2013). Nevertheless, only four studies used the FES-I or Short FES-I to measure FOF in their participants (Tinetti *et al.* 1994; van Haastregt *et al.* 2000; Clemson *et al.* 2004; Markle-Reid *et al.* 2010).

The Timed Up and Go Test (TUG) was used to identify individuals at risk of falls in three studies (Day *et al.* 2002; Clemson *et al.* 2004; Shumway-Cook *et al.* 2007). Albeit, a systematic review and meta-analysis of 10 trials found the TUG to have limited predicative ability in identifying falls risk in community-dwelling older adults (Barry *et al.* 2014). The high level of heterogeneity across the included studies makes it difficult to determine whether or not all individuals were at a definite falls risk. Considering some trials are using outcome measures that have been shown to be poor predictors of outcome, it must be questioned if the correct population are being recruited.

Strengths and weaknesses of the study

Strengths of this systematic review and meta-analysis include the use of PRIMSA guidelines and the robust methods used throughout (Moher *et al.* 2009). The broad search strategy employed across various search engines, along with the stringent methods to identify studies, further support the strength of this study. The use of a second author to review studies suitable for inclusion further justify its' strength. Strict methods were followed in the appraisal and synthesis of the study's findings, using a quality assessment tool supported by research (Zeng *et al.* 2015). The data collected was synthesised and analysed appropriately.

The high levels of heterogeneity of the studies identified was a limitation to this review. Heterogeneity was high in terms of the methods of participant recruitment, interventions provided and outcomes measured. Although heterogeneity levels were high, the use of a random effects model allowed for the expected high levels of heterogeneity in a complex intervention (Bartolucci and Hillegass 2010). Only English language studies were included due to time restrictions.

Throughout all studies included, there were varying outcome measures used to determine the effectiveness of an intervention. The lack of standardised outcome measure makes the interpretation of the pooled meta-analysis more difficult and may reduce the robustness of the meta-analysis (R.M. Turner *et al.* 2012). Some caution may be taken in interpreting the results. No study provided follow-up for greater than one year, which limits the ability to determine the long-term impact of multifactorial interventions.

Clinical and policy implications

The current NICE guidelines and those provided by the AGS/BGS advocate for multifactorial assessment and intervention for falls prevention in community-dwelling older adults (Kenny *et al.* 2011; National Institute for Health and Care Excellence 2013). Both guidelines recommend that older adults be questioned on their falls history and any difficulties with gait or balance when encountering a healthcare professional to help identify those at risk of falling. Only two of the studies included in this review used such criteria in recruiting participants

(Clemson *et al.* 2004; Markle-Reid *et al.* 2010). Despite the fact that these NICE guidelines were published in 2013, earlier NICE guidelines provided similar recommendations (National Institute for Clinical Excellence 2004).

Granting these recommendations may help identify those deemed a falls risk early on, the details of the multifactorial assessment to be carried out as the next step are vague in both sets of guidelines. While the guidelines recommend assessments to be carried out in areas such as balance, gait and mobility, no specific outcome measures are advised for use. This can be leading to clinicians using outcome measures that may not necessarily be most appropriate. In a typical clinical environment, outcome measures adopted by clinicians need to be easy-to-use and time efficient (Hester and Wei 2013). The practicalities of all interventions provided in practice, whether it be multifactorial interventions or not, must always be considered.

The guidelines provided by the AGS/BGS and NICE could be more explicit in explaining the precise details of their recommendations. If this was the case, it may encourage more clinicians and researchers to use these clinical guidelines in their practice, and as a result, improve the uniformity of the assessments and interventions provided (Stenberg and Wann-Hansson 2011). In addition, future systematic reviews and meta-analyses may not have heterogeneity as a limiter to their findings.

While definite and comprehensive guidelines may not be available for clinicians in identifying community-dwelling older adults who are a falls risk and subsequent intervention(s) to provide, clinicians can still take from the current evidence base that exists. From this systematic review and meta-analysis, multifactorial interventions have a significant effect on falls risk and activity limitation in community-dwelling older adults. The evidence would suggest that addressing as many of the identified risk factors as possible may be the preferred treatment approach (Tinetti and Kumar 2010).

By following the algorithm developed by the AGS/BGS targeting falls prevention for community-dwelling older adults, it would help clinicians ensure they are following up-to-date research (Kenny *et al.* 2011). Ideally clinicians should focus on using assessment tools that are validated and reliable in this population, such as the FES-I or the Short FES-I (Yardley et al. 2005; Kempen et al. 2008). From our results, multifactorial interventions could be one component of a treatment plan.

In establishing those at a higher risk of falls, clinicians can use the risks that have been identified and use these as their focus for their intervention. If necessary, clinicians can refer

onwards to the services they deem necessary. As Moore *et al.* (2010) described, a multifactorial intervention provided by healthcare professionals in the community can reduce the number of falls in community-dwelling older adults from 97.7% at baseline to 46.5% at follow-up 18 months later, on average. Although the intervention provided by Moore *et al.* (2010) was not randomised and only observational, it demonstrates the role specially trained clinicians can play in one interaction. The methods used by Moore *et al.* (2010) could be easily reproduced by clinicians in the community, involving one clinician assessing an individual and putting the required interventions in place. In doing so, patient outcomes can be improved.

Areas for further research

According to our results, multifactorial interventions have the potential to influence the falls risk and activity limitations for community-dwelling older adults. The research pooled in this review was highly heterogenous, which may alter the reliability of our results.

Future research could focus on gathering data from clinicians and researchers who are using evidence-based interventions, such as those described by (Kenny *et al.* 2011). To strengthen the research in this area into the future, researchers could focus on carrying out larger, multi-centre trials (Sullivan 2011). To improve reporting of RCT's, the CONSORT statement was published (Schulz *et al.* 2010). Only one study in this review stated in their methods that the CONSORT statement would be followed (Markle-Reid *et al.* 2010). If future RCT's carried out in this area adhered to the CONSORT statement, the completeness and quality of these RCT's could improve (L. Turner *et al.* 2012).

While much research has been carried out focusing on interventions for falls prevention in community-dwelling older adults, little emphasis has been placed on the impact of these interventions on the individual themselves and their family/carer. Research would suggest that caregivers have a pivotal role in falls prevention because of their close relationship with the individual, are a trusted source of information and are able to influence the older adult at risk of falling (Faes *et al.* 2010). A prospective cohort study carried out by Dow *et al.* (2013) recruited 96 community-dwelling older adults who were care recipients and their carers over a year. Due to a fall, 24% of the care-givers reported altering their typical routine and reducing their own social activities. The care-givers reported the concern of a fall recurring and the inclination to want to prevent further falls led them to having increased vigilance. Ideally, the

care-givers would be provided with the necessary resources to reduce the risk of falls recurring, without having a major impact on their own life.

Some research would suggest that those who have suffered a fall suffer both physical and psychological difficulties post-fall (Chang *et al.* 2010). Current research that has been focusing on multifactorial interventions has not involved the individual's family/carer, or considered the individual themselves. As far as the author is aware, no qualitative research has been carried out in conjunction with multifactorial intervention targeting community-dwelling older adults. Future research encompassing this would help gain greater outcomes for all parties involved (Ploeg *et al.* 2017).

Conclusion

This systematic review and meta-analysis would suggest that multifactorial interventions are favoured as a falls prevention intervention for falls risk and activity limitation, but not for falls rate, strength (knee extension), mobility, mental health, social participation or fear of falling in community-dwelling older adults. Future research should focus on utilising evidence based interventions that are standardised, to reduce the levels of heterogeneity between the existing research. While multifactorial interventions are beneficial in some aspects of falls prevention, the requirement for a more defined and comprehensive intervention persists.

References

Barry, E., Galvin, R., Keogh, C., Horgan, F. and Fahey, T. (2014) 'Is the Timed Up and Go test a useful predictor of risk of falls in community dwelling older adults: a systematic review and meta- analysis', *Bmc Geriatrics*, 14, 14, available: http://dx.doi.org/10.1186/1471-2318-14-14.

Bartolucci, A.A. and Hillegass, W.B. (2010) 'Overview, Strengths, and Limitations of Systematic Reviews and Meta-Analyses' in Chiappelli, F., ed., *Evidence-Based Practice: toward Optimizing Clinical Outcomes*, Berlin: Springer-Verlag Berlin, 17-33, available: https://doi.org/10.1007/978-3-642-05025-1_2.

Bruce, J., Ralhan, S., Sheridan, R., Westacott, K., Withers, E., Finnegan, S., Davison, J., Martin, F.C., Lamb, S.E., Pre, F.I.T.I.M.G. and Pre, F.I.T.S.G. (2017) 'The design and development of a complex multifactorial falls assessment intervention for falls prevention: The Prevention of Falls Injury Trial (PreFIT)', *Bmc Geriatrics*, 17, 13, available: http://dx.doi.org/10.1186/s12877-017-0492-6.

Central Statistics Office (2013), *Population and Labour Force Projections 2016-2046* [dataset], Central Statistics Office, Ireland, available: http://www.cso.ie/en/media/csoie/releasespublications/documents/population/2013/poplabfor2016_2046.pdf [accessed 12 April 2017].

Central Statistics Office (2017*) Census 2016 Summary Results - Part 1* [dataset], Central Statistics Office, Ireland, available: http://www.cso.ie/en/media/csoie/newsevents/documents/census2016summaryresultspart1/Census2016SummaryPart1.pdf [accessed 12 April 2017].

Chang, N.T., Chi, L.Y., Yang, N.P. and Chou, P. (2010) 'The Impact of Falls and Fear of Falling on Health-Related Quality of Life in Taiwanese Elderly', *Journal of Community Health Nursing*, 27(2), 84-95, available: http://dx.doi.org/10.1080/07370011003704958.

Clegg, A., Young, J., Iliffe, S., Rikkert, M.O. and Rockwood, K. (2013) 'Frailty in elderly people', *Lancet*, 381(9868), 752-762, available: http://dx.doi.org/10.1016/s0140-6736(12)62167-9.

Clemson, L., Cumming, R.G., Kendig, H., Swann, M., Heard, R. and Taylor, K. (2004) 'The effectiveness of a community-based program for reducing the incidence of falls in the elderly: a randomized trial', *J Am Geriatr Soc*, 52(9), 1487-94, available: http://dx.doi.org/10.1111/j.1532-5415.2004.52411.x.

Day, L., Fildes, B., Gordon, I., Fitzharris, M., Flamer, H. and Lord, S. (2002) 'Randomised factorial trial of falls prevention among older people living in their own homes', *Bmj*, 325(7356), 128, available: https://doi.org/10.1136/bmj.325.7356.128.

Day, L.M. (2013) 'Fall Prevention Programs for Community-Dwelling Older People Should Primarily Target a Multifactorial Intervention Rather Than Exercise as a Single Intervention', *Journal of the American Geriatrics Society*, 61(2), 284-285, available: http://dx.doi.org/10.1111/jgs.12095_3.

de Vries, O.J., Peeters, G., Elders, P.J.M., Muller, M., Knol, D.L., Danner, S.A., Bouter, L.M. and Lips, P. (2010) 'Multifactorial Intervention to Reduce Falls in Older People at High Risk of Recurrent Falls A Randomized Controlled Trial', *Archives of Internal Medicine*, 170(13), 1110-1117, available: http://dx.doi.org/10.1001/archinternmed.2010.169.

Deandrea, S., Lucenteforte, E., Bravi, F., Foschi, R., La Vecchia, C. and Negri, E. (2010) 'Risk Factors for Falls in Community-dwelling Older People A Systematic Review and Meta-analysis', *Epidemiology*, 21(5), 658-668, available: http://dx.doi.org/10.1097/EDE.0b013e3181e89905.

Delbaere, K., Close, J.C.T., Mikolaizak, A.S., Sachdev, P.S., Brodaty, H. and Lord, S.R. (2010) 'The Falls Efficacy Scale International (FES-I). A comprehensive longitudinal validation study', *Age and Ageing*, 39(2), 210-216, available: http://dx.doi.org/10.1093/ageing/afp225.

Dow, B., Meyer, C., Moore, K.J. and Hill, K.D. (2013) 'The impact of care recipient falls on caregivers', *Australian Health Review*, 37(2), 152-157, available: http://dx.doi.org/10.1071/ah12168.

Faes, M.C., Reelick, M.F., Banningh, L., de Gier, M., Esselink, R.A. and Rikkert, M.G.O. (2010) 'Qualitative study on the impact of falling in frail older persons and family caregivers: Foundations for an intervention to prevent falls', *Aging & Mental Health*, 14(7), 834-842, available: http://dx.doi.org/10.1080/13607861003781825.

Fairhall, N., Sherrington, C., Lord, S.R., Kurrle, S.E., Langron, C., Lockwood, K., Monaghan, N., Aggar, C. and Cameron, I.D. (2014) 'Effect of a multifactorial, interdisciplinary intervention on risk factors for falls and fall rate in frail older people: a randomised controlled trial', *Age And Ageing*, 43(5), 616-622, available: http://dx.doi.org/10.1093/ageing/aft204.

Gates, S., Fisher, J.D., Cooke, M.W., Carter, Y.H. and Lamb, S.E. (2008) 'Multifactorial assessment and targeted intervention for preventing falls and injuries among older people in community and emergency care settings: systematic review and meta-analysis', *British Medical Journal*, 336(7636), 130-133, available: http://dx.doi.org/10.1136/bmj.39412.525243.BE.

Gazibara, T., Kurtagic, I., Kisic-Tepavcevic, D., Nurkovic, S., Kovacevic, N. and Pekmezovic, T. (2017) 'Falls, risk factors and fear of falling among persons older than 65 years of age', *Psychogeriatrics*, 17(4), 215-223, available: http://dx.doi.org/10.1111/psyg.12217.

Gillespie, L.D., Robertson, M.C., Gillespie, W.J., Sherrington, C., Gates, S., Clemson, L.M. and Lamb, S.E. (2012) 'Interventions for preventing falls in older people living in the community', *Cochrane Database of Systematic Reviews*, (9), available: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD007146.pub3/abstract.

Health Service Executive (2008) *Strategy to Prevent Falls and Fractures in Ireland's Ageing Population*, Health Service Executive, Ireland, available: http://www.hse.ie/eng/services/publications/olderpeople/Executive_Summary_-_Strategy_to_Prevent_Falls_and_Fractures_in_Ireland%E2%80%99s_Ageing_Population.pdf [accessed 08 April 2017].

Heinrich, S., Rapp, K., Rissmann, U., Becker, C. and Konig, H.H. (2010) 'Cost of falls in old age: a systematic review', *Osteoporosis International*, 21(6), 891-902, available: http://dx.doi.org/10.1007/s00198-009-1100-1.

Hendriks, M.R., Bleijlevens, M.H., van Haastregt, J.C., Crebolder, H.F., Diederiks, J.P., Evers, S.M., Mulder, W.J., Kempen, G.I., van Rossum, E., Ruijgrok, J.M., Stalenhoef, P.A. and van Eijk, J.T. (2008) 'Lack of effectiveness of a multidisciplinary fall-prevention program in elderly people at risk: a randomized, controlled trial', *J Am Geriatr Soc*, 56(8), 1390-7, available: http://dx.doi.org/10.1111/j.1532-5415.2008.01803.x.

Hester, A.L. and Wei, F.F. (2013) 'Falls in the community: state of the science', *Clinical Interventions in Aging*, 8, 675-679, available: http://dx.doi.org/10.2147/cia.s44996.

Higgins, J. and Green, S. (2011) *Cochrane Handbook for Systematic Reviews of Interventions*, West Sussex, England: John Wiley & Sons Ltd.

Higgins, J.P.T., Altman, D.G., Gotzsche, P.C., Juni, P., Moher, D., Oxman, A.D., Savovic, J., Schulz, K.F., Weeks, L., Sterne, J.A.C., Cochrane Bias Methods, G. and Cochrane Stat Methods, G. (2011) 'The Cochrane Collaboration's tool for assessing risk of bias in randomised trials', *Bmj-British Medical Journal*, 343, 9, available: http://dx.doi.org/10.1136/bmj.d5928.

Hozo, S.P., Djulbegovic, B. and Hozo, I. (2005) 'Estimating the mean and variance from the median, range, and the size of a sample', *BMC Med Res Methodol*, 5, 13, available: http://dx.doi.org/10.1186/1471-2288-5-13.

Jin, K.L., Simpkins, J.W., Ji, X.M., Leis, M. and Stambler, I. (2015) 'The Critical Need to Promote Research of Aging and Aging-related Diseases to Improve Health and Longevity of the Elderly Population', *Aging and Disease*, 6(1), 1-5, available: http://dx.doi.org/10.14336/AD.2014.1210.

Karlsson, M.K., Vonschewelov, T., Karlsson, C., Coster, M. and Rosengen, B.E. (2013) 'Prevention of falls in the elderly: a review', *Scand J Public Health*, 41(5), 442-54, available: http://dx.doi.org/10.1177/1403494813483215.

Kempen, G., Yardley, L., van Haastregt, J.C.M., Zijlstra, G.A.R., Beyer, N., Hauer, K. and Todd, C. (2008) 'The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling', *Age and Ageing*, 37(1), 45-50, available: http://dx.doi.org/10.1093/ageing/afm157.

Kenny, R.A.M., Rubenstein, L.Z., Tinetti, M.E., Brewer, K., Cameron, K.A., Capezuti, E.A., John, D.P., Lamb, S., Martin, F., Rockey, P.H., Suther, M., Peterson, E.W., Amer Geriatrics, S. and British Geriatrics, S. (2011) 'Summary of the Updated American Geriatrics Society/British Geriatrics Society Clinical Practice Guideline for Prevention of Falls in Older Persons', *Journal of the American Geriatrics Society*, 59(1), 148-157, available: http://dx.doi.org/10.1111/j.1532-5415.2010.03234.x.

Lord, S.R., Tiedemann, A., Chapman, K., Munro, B., Murray, S.M. and Sherrington, C. (2005) 'The effect of an individualized fall prevention program on fall risk and falls in older people: A randomized, controlled trial', *Journal of the American Geriatrics Society*, 53(8), 1296-1304, available: http://dx.doi.org/10.1111/j.1532-5415.2005.53425.x.

Markle-Reid, M., Browne, G., Gafni, A., Roberts, J., Weir, R., Thabane, L., Miles, M., Vaitonis, V., Hecimovich, C., Baxter, P. and Henderson, S. (2010) 'The effects and costs of a multifactorial and interdisciplinary team approach to falls prevention for older home care clients 'at risk' for falling: A randomized controlled trial', *Canadian Journal on Aging*, 29(1), 139-161, available: http://dx.doi.org/10.1017/S0714980809990377.

Mikolaizak, A.S., Lord, S.R., Tiedemann, A., Simpson, P., Caplan, G.A., Bendall, J., Howard, K., Webster, L., Payne, N., Hamilton, S., Lo, J., Ramsay, E., O'Rourke, S., Roylance, L. and Close, J.C. (2017) 'A multidisciplinary intervention to prevent subsequent falls and health service use following fall-related paramedic care: a randomised controlled trial', *Age And Ageing*, 46(2), 200-207, available: http://dx.doi.org/10.1093/ageing/afw190.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G. and Grp, P. (2009) 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement', *Annals of Internal Medicine*, 151(4), 264-W64, available: http://dx.doi.org/10.7326/0003-4819-151-4-200908180-00135.

Moore, M., Williams, B., Ragsdale, S., LoGerfo, J.P., Goss, J.R., Schreuder, A.B. and Phelan, E.A. (2010) 'Translating a Multifactorial Fall Prevention Intervention into Practice: A Controlled Evaluation of a Fall Prevention Clinic', *Journal of the American Geriatrics Society*, 58(2), 357-363, available: http://dx.doi.org/10.1111/j.1532-5415.2009.02683.x.

Murray, C.J.L., Vos, T., Lozano, R., Naghavi, M., Flaxman, A.D., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J.A., Abdalla, S., Aboyans, V., Abraham, J., Ackerman, I., Aggarwal, R., Ahn, S.Y., Ali, M.K., Alvarado, M., Anderson, H.R., Anderson, L.M., Andrews, K.G., Atkinson, C., Baddour, L.M., Bahalim, A.N., Barker-Collo, S., Barrero, L.H., Bartels, D.H., Basanez, M.G., Baxter, A., Bell, M.L., Benjamin, E.J., Bennett, D., Bernabe, E., Bhalla, K., Bhandari, B., Bikbov, B., Bin Abdulhak, A., Birbeck, G., Black, J.A., Blencowe, H., Blore, J.D., Blyth, F., Bolliger, I., Bonaventure, A., Boufous, S.A., Bourne, R., Boussinesq, M., Braithwaite, T., Brayne, C., Bridgett, L., Brooker, S., Brooks, P., Brugha, T.S., Bryan-Hancock, C., Bucello, C., Buchbinder, R., Buckle, G., Budke, C.M., Burch, M., Burney, P., Burstein, R., Calabria, B., Campbell, B., Canter, C.E., Carabin, H., Carapetis, J., Carmona, L., Cella, C., Charlson, F., Chen, H.L., Cheng, A.T.A., Chou, D., Chugh, S.S., Coffeng, L.E., Colan, S.D., Colquhoun, S., Colson, K.E., Condon, J., Connor, M.D., Cooper, L.T., Corriere, M., Cortinovis, M., De Vaccaro, K.C., Couser, W., Cowie, B.C., Criqui, M.H., Cross, M., Dabhadkar, K.C., Dahiya, M., Dahodwala, N., Damsere-Derry, J., Danaei, G., Davis, A., De Leo, D., Degenhardt, L., Dellavalle, R., Delossantos, A., Denenberg, J., Derrett, S., Des Jarlais, D.C., Dharmaratne, S.D., *et al.* (2012) 'Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010', *Lancet*, 380(9859), 2197-2223, available: http://dx.doi.org/10.1016/s0140-6736(12)61689-4.

National Institute for Clinical Excellence (2004) *Falls: the assessment and prevention of falls in older people* (CG21), United Kingdom, available: https://www.nice.org.uk/guidance/cg21 [accessed 10 April 2017].

National Institute for Health and Care Excellence (2013) Falls in older people: assessing risk and prevention (CG121), United Kingdom, available: https://www.nice.org.uk/guidance/cg161 [accessed 10 April 2017].

Ploeg, J., Matthew-Maich, N., Fraser, K., Dufour, S., McAiney, C., Kaasalainen, S., Markle-Reid, M., Upshur, R., Cleghorn, L. and Emili, A. (2017) 'Managing multiple chronic conditions in the community: a Canadian qualitative study of the experiences of older adults, family caregivers and healthcare providers', *Bmc Geriatrics*, 17, 15, available: http://dx.doi.org/10.1186/s12877-017-0431-6.

Pohl, P., Nordin, E., Lundquist, A., Bergstrom, U. and Lundin-Olsson, L. (2014) 'Community-dwelling older people with an injurious fall are likely to sustain new injurious falls within 5 years - a prospective long-term follow-up study', *Bmc Geriatrics*, 14, 7, available: http://dx.doi.org/10.1186/1471-2318-14-120.

Prince, M.J., Wu, F., Guo, Y.F., Robledo, L.M.G., O'Donnell, M., Sullivan, R. and Yusuf, S. (2015) 'The burden of disease in older people and implications for health policy and practice', *Lancet*, 385(9967), 549-562, available: http://dx.doi.org/10.1016/s0140-6736(14)61347-7.

Russell, M.A., Hill, K.D., Day, L.M., Blackberry, I., Schwartz, J., Giummarra, M.J., Dorevitch, M., Ibrahim, J.E., Dalton, A.C. and Dharmage, S.C. (2010) 'A Randomized Controlled Trial of a Multifactorial Falls Prevention Intervention for Older Fallers Presenting to Emergency Departments', *Journal of the American Geriatrics Society*, 58(12), 2265-2274, available: http://dx.doi.org/10.1111/j.1532-5415.2010.03191.x.

Scheffer, A.C., van Hensbroek, P.B., van Dijk, N., Luitse, J.S., Goslings, J.C., Luigies, R.H. and de Rooij, S.E. (2013) 'Risk factors associated with visiting or not visiting the accident & emergency department after a fall', *BMC Health Serv Res*, 13, 286, available: http://dx.doi.org/10.1186/1472-6963-13-286.

Schulz, K.F., Altman, D.G., Moher, D. and Grp, C. (2010) 'CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials', *Journal of Clinical Epidemiology*, 63(8), 834-840, available: http://dx.doi.org/10.1016/j.jclinepi.2010.02.005.

Shumway-Cook, A., Silver, I.F., LeMier, M., York, S., Cummings, P. and Koepsell, T.D. (2007) 'Effectiveness of a community-based multifactorial intervention on falls and fall risk factors in community-living older adults: a randomized, controlled trial', *J Gerontol A Biol Sci Med Sci*, 62(12), 1420-7, available: https://doi.org/10.1093/gerona/62.12.1420

Stenberg, M. and Wann-Hansson, C. (2011) 'Health Care Professionals' Attitudes and Compliance to Clinical Practice Guidelines to Prevent Falls and Fall Injuries', *Worldviews on Evidence-Based Nursing*, 8(2), 87-95, available: http://dx.doi.org/10.1111/j.1741-6787.2010.00196.x.

Sullivan, G.M. (2011) 'Getting off the "gold standard": randomized controlled trials and education research', *J Grad Med Educ*, 3(3), 285-9, available: http://dx.doi.org/10.4300/jgme-d-11-00147.1.

Taylor and Francis Online (2017) *Disability and Rehabilitation Journal - Instructions for Authors*, available: http://www.tandfonline.com/action/authorSubmission?journalCode=idre20&page=instructions [accessed 14 November 2017].

The Cochrane Collaboration (2014) Review Manager (Revman) [Computer program]. Version 5.3. *Copenhagen: The Nordic Cochrane Centre*

Tinetti, M.E., Baker, D.I., McAvay, G., Claus, E.B., Garrett, P., Gottschalk, M., Koch, M.L., Trainor, K. and Horwitz, R.I. (1994) 'A multifactorial intervention to reduce the risk of falling among elderly people living in the community', *N Engl J Med*, 331(13), 821-7, available: http://dx.doi.org/10.1056/nejm199409293311301.

Tinetti, M.E. and Kumar, C. (2010) 'The Patient Who Falls "It's Always a Trade-off"', *Jama-Journal of the American Medical Association*, 303(3), 258-266, available: http://dx.doi.org/10.1001/jama.2009.2024.

Turner, L., Shamseer, L., Altman, D.G., Schulz, K.F. and Moher, D. (2012) 'Does use of the CONSORT Statement impact the completeness of reporting of randomised controlled trials published in medical journals? A Cochrane review', *Syst Rev*, 1, 60, available: http://dx.doi.org/10.1186/2046-4053-1-60.

Turner, R.M., Davey, J., Clarke, M.J., Thompson, S.G. and Higgins, J.P.T. (2012) 'Predicting the extent of heterogeneity in meta-analysis, using empirical data from the Cochrane Database of Systematic Reviews', *International Journal of Epidemiology*, 41(3), 818-827, available: http://dx.doi.org/10.1093/ije/dys041.

Tuunainen, E., Rasku, J., Jantti, P. and Pyykko, I. (2014) 'Risk factors of falls in community dwelling active elderly', *Auris Nasus Larynx*, 41(1), 10-16, available: http://dx.doi.org/10.1016/j.anl.2013.05.002.

United Nations (2017) *World Population Prospects: The 2017 Revision, Key Findings and Advance Tables*, United Nations, Department of Economic and Social Affairs, Population Division, New York, United States of America, ESA/P/WP/248, available: https://esa.un.org/unpd/wpp/Publications/ [accessed 10 January 2018].

van Haastregt, J.C., Diederiks, J.P., van Rossum, E., de Witte, L.P., Voorhoeve, P.M. and Crebolder, H.F. (2000) 'Effects of a programme of multifactorial home visits on falls and mobility impairments in elderly people at risk: randomised controlled trial', *Bmj*, 321(7267), 994-8, available: https://doi.org/10.1136/bmj.321.7267.994.

World Health Organisation (2007) *Global Report on Falls Prevention in Older Age*, Geneva, Switzerland, available: http://www.who.int/ageing/publications/Falls_prevention7March.pdf [accessed 26 September 2017].

World Health Organisation (2014) *World Health Statistics 2014*, World Health Organisation, Geneva, Switzerland available: http://www.who.int/gho/publications/world_health_statistics/2014/en/ [accessed 10 January 2018].

Yardley, L., Beyer, N., Hauer, K., Kempen, G., Piot-Ziegler, C. and Todd, C. (2005) 'Development and initial validation of the Falls Efficacy Scale-International (FES-I)', *Age and Ageing*, 34(6), 614-619, available: http://dx.doi.org/10.1093/ageing/afi196.

Yumi, S. and Yukari, O. (2013) 'Risk Factors of Fall among the Community-dwelling Elderly: Fear of Falling, History of Fall, Physical Function, and Perceptual Difference between Actual and Estimated Performance', *Rigakuryoho Kagaku*, 28(6), 771-778, available: http://dx.doi.org/10.187/1189-6831-52-361.

Zeng, X., Zhang, Y., Kwong, J.S., Zhang, C., Li, S., Sun, F., Niu, Y. and Du, L. (2015) 'The methodological quality assessment tools for preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: a systematic review', *J Evid Based Med*, 8(1), 2-10, available: http://dx.doi.org/10.1111/jebm.12141.

Appendix 1

Date	Search Engine	Search Terms	Limiters	Number of Items Retrieved
03-10-2017	Cochrane	[(Geriatric* OR Elder* OR age* OR old-age* OR pensioner* OR ag*ing OR aged OR senior OR old* OR retired) AND	Title, Abstract, Keywords	495
03-10-2017	Web of Science		Title	8
03-10-2017	Scopus	(coordinated OR intergrated OR multidisciplinary OR interdisciplinary OR multifactorial) AND	Title, Abstract, Keywords	1,390
03-10-2017	PubMed	(care OR case OR management OR intervention) AND	Title/Abstract	713
03-10-2017	CINAHL	("accidental fall" OR "accidental falls" OR fall OR falling OR faller OR fall*)]	Abstract	255
03-10-2017	MEDLINE		Abstract	504

Table 1: Initial Search Strategy

Appendix 2

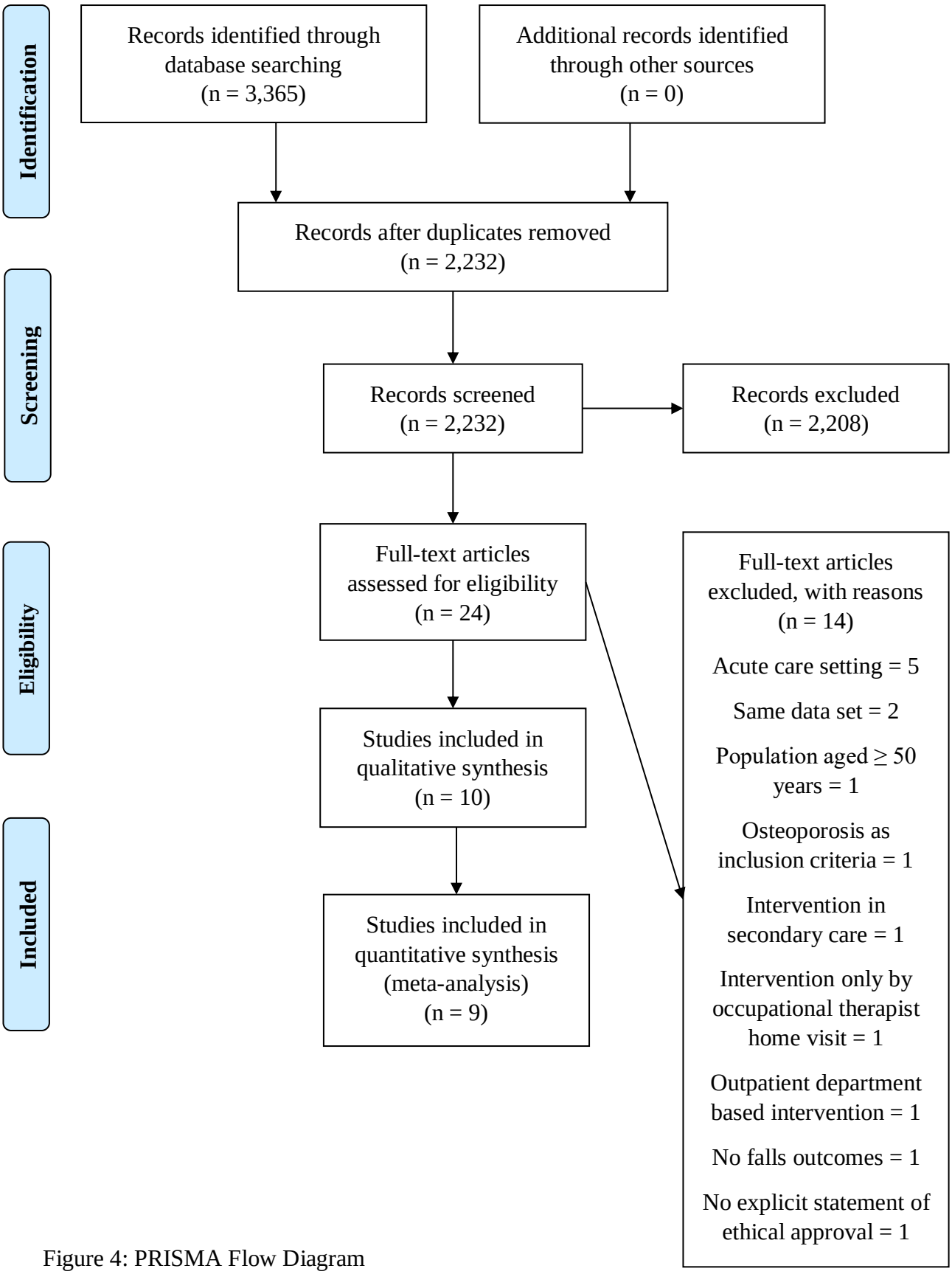

Figure 4: PRISMA Flow Diagram

Author	Year	Country	Study Design	Population	Intervention	Control	Outcomes Measured
Clemson et al.	2004	Australia	RCT	n = 310 community-dwelling men and women aged ≥70, had a fall in previous year or felt they were at risk of falling, < 3 errors on Short Portable Mental Status Questionnaire, English speaking, independently able to leave their home	n = 157 7/52 multifaceted community-based program created by a team of experts in falls prevention, facilitated by an OT. Key content areas – LL balance & strength exercises, coping with visual loss and regular visual screening, medication review, home safety – behavioural and environmental, community safety + follow up home visit within 6/52 of final session and at 3/12 post a booster session at	n = 153 2 social visits from OT students – students instructed to not discuss falls or falls prevention	Occurrence of falls 30-item Falls Behavioural (FaB) Scale MES MFES PASE SF-36 Physical & Mental Health Components Worry Scale Get-up and Go Test

Table 2: Characteristics of Included Studies

Author	Year	Country	Study Design	Population	Intervention	Control	Outcomes Measured
Day et al.	2002	Australia	RCT	n = 1,107 community-dwelling adults aged ≥70 living in their own home (or similar), expecting to stay in the same area for two years (except for short absences), had been moderately physically activity (with a balance component) in the previous 2/12, could walk 10-20 metres without needing a rest, no severe respiratory/cardiac disease/psychiatric illness/dysphagia, no recent home modifications, had an education & language adjusted score <4 on the short portable mental status questionnaire, had	*1.* n = 135 Strength and balance exercise – 60 mins exercise class 1/7 for 15/52 *2.* n = 136 Home hazard - home hazards either removed or changed by participants or home maintenance programme *3.* n = 139 Vision – referral to eye care provider, GP or local optometrist (if needed) *4.* n = 135 intervention 1 + intervention 2 *5.* n = 136 intervention 1 + intervention 3 *6.* n = 137 intervention 2 + intervention 3 *7.* n = 135 intervention 1 + intervention 2 + intervention 3	n = 137 brochure on eye care for over 40's	Rate of falls Number of fallers Quadriceps strength (stronger side) Postural sway on foam pad Maximal balance range (cm) Coordinated stability TUG High contrast acuity in best eye Low contrast acuity in best eye Dot pattern Field of view in best eye

Table 2: Characteristics of Included Studies (Continued)

Author	Year	Country	Study Design	Population	Intervention	Control	Outcomes Measured
Fairhall et al.	2014	Australia	RCT	n = 241 community-dwelling older people, aged 70+, MMSE >18, frail according to the Cardiovascular Health Study criteria	n = 120 12/12 multifactorial intervention by 2 physiotherapists (10 physiotherapy visits in 12/12 study period focused on exercise. HEP of balance and LL strength training in standing – 20-30 mins 3-5/7), a geriatrician, rehabilitation	n = 121 usual care	Fall rate PPA SPPB 4m walk test
Hendriks et al.	2008	Netherlands	RCT	n = 333 community-dwelling older people aged ≥65 who attended the University of Maastrict ED due to a fall, Dutch speaking, score >4 on the Abbreviated Mental Test, admitted for <4/52 to a hospital, not permanently wheelchair-bound/bedridden	n = 166 multifactorial intervention – assessment by a geriatrician, rehabilitation physician and geriatric nurse. Recommendations and indications for referral sent to the participants GP and action then taken at the GP's discretion. OT home assessment within 1 month of the geriatric assessment, recommendations sent to GP and technical aids and adaptations delivered by social and community services	n = 167 usual care	Falls Recurrent falls Injurious falls Time to first fall HADS Activity avoidance Recuperation from the index fall Perceived health Groningen Activity Restriction Scale Fear of falling QoL Health complaints

Table 2: Characteristics of Included Studies (Continued)

Author	Year	Country	Study Design	Population	Intervention	Control	Outcomes Measured
Lord et al.	2005	Australia	RCT	n = 620 community dwelling people ≥ 75 years with a low score on the PPA Test, excluded if – blind, had a diagnosis of Parkinson's Disease or Short Portable Mental Status Questionnaire score < 7, minimal English language skills	*1.* Extensive Intervention Group n = 210 – individualised exercise 12/12 intervention - 2/7 in 4 x 10-12/52 terms, focusing on flexibility, strength, balance and co-ordination visual intervention of an eye examination +/- glasses (if required) + peripheral sensation counselling intervention of how decreased LL sensation can result in reduced stability *2.* Minimal Intervention Group n = 206 – received a report explaining their falls risk, a copy of their test results and specific recommendations for falls prevention based on their results	n = 204 no intervention	Number of falls & injurious falls Falls risk Strength – ankle dorsiflexion, knee extension, knee flexion Reaction time – finger press, foot press Balance and transfers – coordinated stability, sit to stand time, sway (eyes open + floor, eyes closed + floor, eyes open + foam, eyes closed + foam) SF-12 Visual – visual acuity high, visual acuity low, edge

Table 2: Characteristics of Included Studies (Continued)

Author	Year	Country	Study Design	Population	Intervention	Control	Outcomes Measured
Markle-Reid et al.	2010	Canada	RCT	n = 109 community-dwelling adults ≥75, MMSE ≤24, competent in English or with translator available, 'at risk' of falling (had fall in previous 12/12, feeling unsteady on feet, having a fear of	n = 55 6/12 multifactorial intervention (home visits by healthcare professionals at least 1/12 for an average of 1 hour) + standard home care services	n = 54 standard home care services	Number of falls & slips & trips SF-36 Functional Health Status & HRQoL POMA SCREEN II CES-D MMSE MFES
Mikolaizak et al.	2017	Australia	RCT	n = 221 adults aged ≥65, who had received an emergency response from paramedics due to a fall-related incident, not in residential aged care facility, sufficient English, no diagnosis of dementia	n = 111 direct support from a research physiotherapist to put in place falls prevention recommendations post-baseline assessment – including referrals for exercise therapy, organising home hazard assessments and OT modifications, organising vision assessments by optometrists, assistance in liaising with healthcare providers and transportation to appointments	n = 110 written advice on addressing their falls-risk and advise to speak to their healthcare provider to help put in place recommended fall prevention interventions	Rate of falls Fall-related injuries Level of adherence to recommendations Ambulance call-outs (fall related) Ambulance call-outs ED presentation (fall-related) ED presentation Hospitalisation (fall-related) Hospitalisation

Table 2: Characteristics of Included Studies (Continued)

Author	Year	Country	Study Design	Population	Intervention	Control	Outcomes Measured
Shumway-Cook et al.	2007	US	RCT	n = 453 community-dwelling adults ≥65, English speaking, have a primary care physician seen within the previous 3 years, independently mobile (including stick or walker), willing to participate in group exercise classes for at least 6/12 but no regular exercise in the previous 3/12, minimal hearing/visual impairments, access to transport, , 10 foot TUG in <30 secs, Pfeiffer Short Portable Mental Status Questionnaire	n = 226 12/12 group exercise class (1 hour 3/7 for up to 12/12) @ community site of participants choice, 6 x1 hour falls prevention education classes every month, fall assessment summary with a copy of the falls prevention guideline sent to participants primary care physician	n = 227 usual care + 2 fall-prevention brochures	Incidence rate of falls Repeated Chair Stand Test Berg Balance Scale TUG
Tinetti et al.	1994	US	Cluster RCT	n = 301 adults residing in the community ≥70, independent ambulation, MMSE ≥20, no participation in vigorous sports/walking for exercise in previous 1/12, ≥1 falls risk factor (postural hypotension, benzodiazepine use, ≥ 4 prescription meds, unsafe T/F's to bath/toilet, environmental hazards for falls, gait impairment, T/F or balance impairment, UL or LL strength or	n = 153 12/12 follow-up interventions (for 3/12) to target specific participants risk factors, decision rules and priority lists used to select standardised intervention protocols for each risk factor	n = 148 Structured interviews by social work students as part of home visits	Incidence of falls Number of fallers FES SIP

Table 2: Characteristics of Included Studies (Continued)

Key Table 2:

Author	Year	Country	Study Design	Population	Intervention	Control	Outcomes Measured
van Haastregt et al.	2000	Netherlands	RCT	n = 316 from 6 general practices (by screening questionnaire) aged ≥ 70 years, community-dwelling, have reported ≥ 2 falls in the previous 6 months or have scored ≥ 3 on the mobility control scale of the short SIP, not bedridden or fully wheelchair dependent, not terminally ill, not receiving home care from a community nurse regularly or not on a waiting list for nursing home admission	n = 159 5 home visits in 1 year from a community nurse, during which screening took place for medical, environmental and behavioural falls risk factors and subsequent advice, referrals and other actions to manage the risks identified. A structured protocol focusing on falls, fear of falling, mobility, physical health, drugs, ADLs, social functioning, cognitive functioning, psychosocial functioning was followed with a checklist for home safety	n = 157 usual care	Number of individuals having 1 fall, >1 fall, an injurious fall, a fall resulting in medical care Perceived gait problems Mobility Range Scale of Short SIP Mobility Control Scale Number of physical complaints Frenchay Activities Index FES Social functioning Loneliness SF-36 Perceived Health & Mental Health

Table 2: Characteristics of Included Studies (Continued)

n sample size, *x/7* x number of days, *x/12* x number of months, *x/52* x number of weeks, *GP* General Practitioner, *OT* Occupational Therapist, *UL* upper limb, *LL* lower limb, *ROM* mange of motion, *ADL's* activities of daily living, *ED* emergency department, *HEP* home exercise programme, *(HR)QoL* (Health Related) Quality of Life, *MES* Mobility Efficacy Scale, *(M)FES* (Modified) Falls Efficacy Scale, *SF-12* 12-Item Short Form health survey, *SF-36* 36-Item Short Form health survey, *TUG* Timed Up and Go, *MMSE* Mini Mental State Examination, *PPA* Physiological Profile Assessment, *HADS* Hospital Anxiety and Depression Scale, *SCREEN II* Seniors in the Community: Risk Evaluation for Eating and Nutrition Questionnaire, *CES-D* Centre for Epidemiological Studies Depression Scale, *POMA* Performance Orientated Mobility Assessment, *SIP* Sickness Impact Profile, *SPPB* Short Physical Performance Battery, *PASE* Physical Activity Scale for the Elderly

	Selection Bias		Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Other Bias	Risk of Bias
Author & Year	**Random Sequence Generation**	**Allocation Concealment**	**Blinding of Personnel & Participants**	**Blinding of Outcome Assessment**	**Incomplete Outcome Data**	**Selective Reporting**	**Other Sources of Bias**	**Overall Risk of Bias**
Clemson et al. 2004	U	U	U	U	U	H	U	H
Day et al. 2002	L	L	U	L	U	H	L	U
Fairhall et al. 2014	L	U	U	H	U	U	U	U
Hendriks et al. 2008	U	U	H	L	L	L	L	U
Lord et al. 2005	L	L	U	U	L	U	L	U
Markle-Reid et al. 2010	L	L	H	U	L	U	U	U
Mikolaizak et al. 2017	L	L	H	U	L	U	U	U
Shumway-Cook et al. 2007	L	L	U	U	L	L	L	U
Tinetti et al. 1994	L	U	U	L	L	L	L	U
van Haastregt et	L	U	U	U	L	L	L	U

Table 3: Quality Assessment of Included Studies Using the Cochrane Risk of Bias Tool

Key Table 3: *H* high risk of bias, *U* unclear risk of bias, *L* low risk of bias

Appendix 5

Impairments

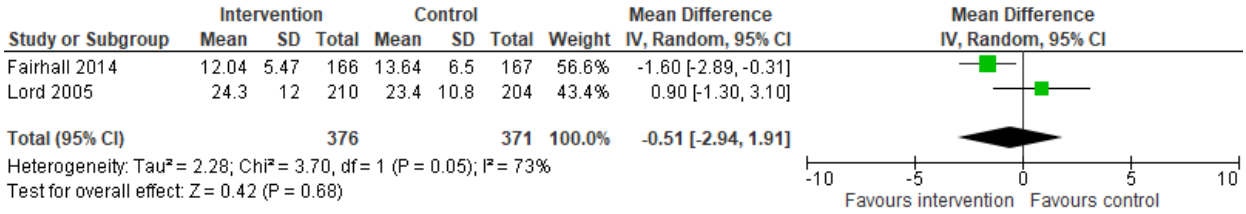

Figure 5: Forest plot for strength (knee extension)

Activity Limitations

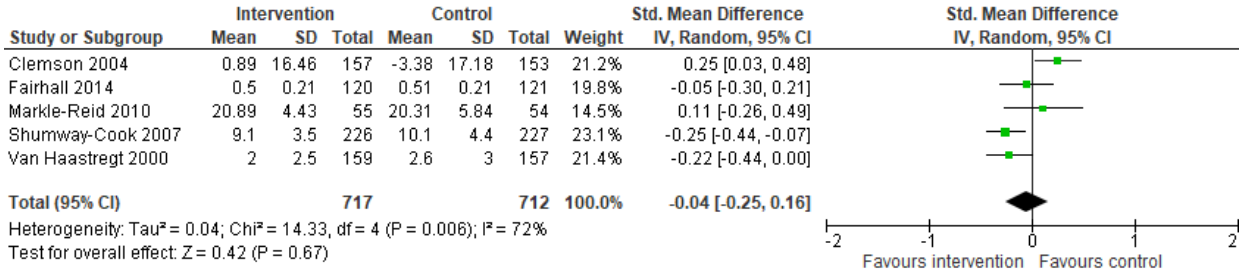

Figure 6: Forest plot for mobility

Participation Restrictions

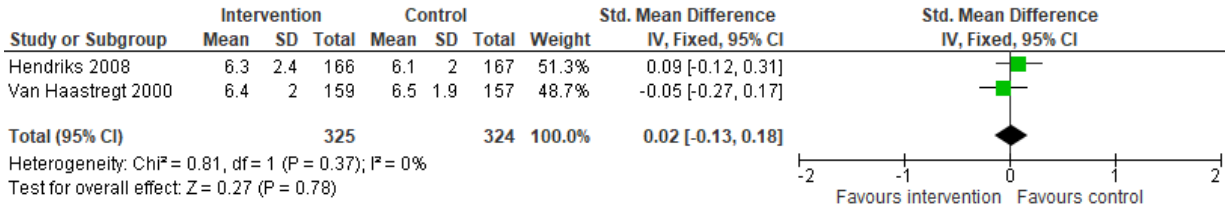

Figure 7: Forest plot for social participation

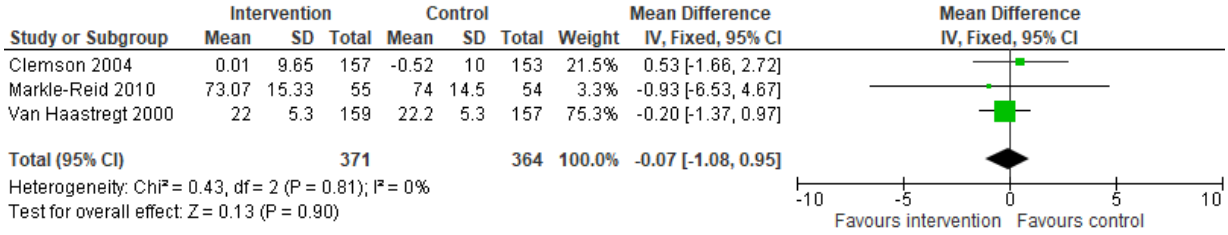

Figure 8: Forest plot for mental health

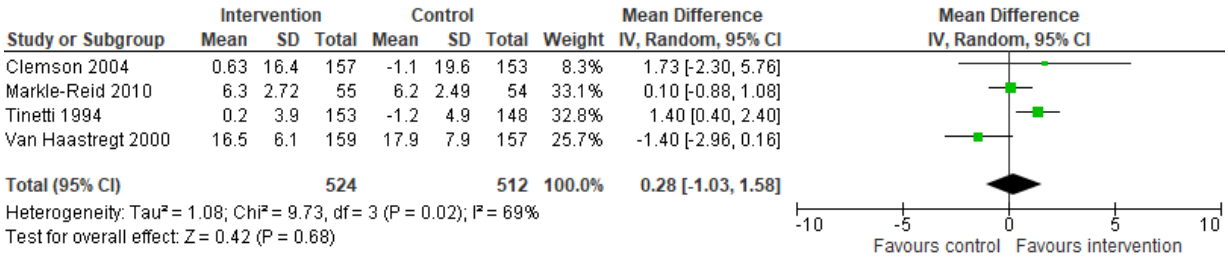

Figure 9: Forest plot for fear of falling