Title page

The use of interactive technology an effective training method to improve combined strength and balance in community-dwelling older adults: a systematic review.

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The use of interactive technology an effective training method to improve combined strength and balance in community-dwelling older adults: a systematic review.

Abstract (149 words)

The number of older adults falling is increasing. Strength and balance training is recommended to reduce falls risk in this population. Low cost interventions, such as interactive technology (IT), are needed. This study reviewed evidence on IT's effectiveness in increasing both strength and balance in community-dwelling older adults. Seven databases (Cochrane Library, PubMed, Scopus, PEDro, CINHAL Plus, TRIP, NICE evidence) were searched in October-November 2017 (March 2020) using the terms: 'older adults', 'interactive technology', 'strength and balance'. 374 papers were initially identified, with four articles selected for quantitative synthesis. These were RCTs, involving 235 participants aged > 65 years, and used exergaming. Leg strength and balance improved in 3/4 studies ($p < 0.05$). Emergent evidence shows that IT, such as exergaming, improves strength and balance in older adults. Such initiatives should be adopted in Public Health/NHS practice as part of a multifaceted approach to reduce falls risk in community-dwelling older adults.

Key words: ageing, exercise, e-health, exergaming, fall reduction

Introduction

Falls in the elderly and interventions

A fall can be defined as "… an unintentional or unexpected loss of balance resulting in coming to rest on the floor, the ground, or an object below knee level" (NICE 2015: 9).

Falls rates for older adults are increasing year on year, annually costing the National Health Service (NHS) more than £2bn (Tian et al. 2013). It is estimated that one in three adults over the age of 65 years and one in two adults over 80 years old will fall at least once in the next 12 months (NICE, 2013). Falls risk is multi-factorial with muscle weakness and poor balance playing a part (Charters, 2013). This is modifiable if an appropriate exercise programme is followed (Charters, 2013). NICE guidance published in 2013 (CG161) stated that for adults who have already fallen a strength and balance exercise programme should be followed to reduce the risk of further falls (NICE, 2013). A minimum dose of 50 hours over a six-month period is required to reduce falls risk (Charters 2013, NICE 2013).

Physical activity guidelines published collectively by the four United Kingdom (UK) Chief Medical Officers in July 2011 recommended that older adults aged 65 years and over should undertake at least 150 minutes of moderate intensity activity or 75 minutes of vigorous activity per week with additional strength, balance and co-ordination training at least twice a week (Department of Health 2011). Nearly half (46.2%) of adults aged 65 – 74 years and two-thirds (67.9%) of adults aged 75 or over are not meeting these recommendations (Sport England 2017). England faces a problem of rising levels of inactivity with age and an ageing population (Guzman-Castillo et al. 2017). One consequence of these changes is increasing numbers of deconditioned older adults with increased risk of falling which presents challenges for Public Health departments (Bleakley et al. 2015).

Local government Public Health departments, Adult Social Care and the NHS are under increasing budgetary pressures as demand for services grows (The Kings Fund 2017a, 2017b). Preventative measures are needed to keep older adults active in later life to delay functional decline and increased risk of falling. Public health concerns around falls are more than just the falls event. After a fall, the potential impact on an older person's quality of life and life satisfaction are significant (Hajek & König 2017). The potential knock-on effects of a fall are injury, fear of falling, inactivity, social isolation, depression and future falls (Li et al. 2003).

A Cochrane Library review conducted by Gillespie et al. (2012) scrutinised studies of exercise interventions for their effectiveness. It concluded that programmes aimed at training strength and balance together were more effective than balance or strength alone.

For the purposes of this paper, community-dwelling older adults means adults that are not living in residential care settings. This paper is focusing specifically on community-dwelling older adults because those living in residential care settings have different levels of falls risk which are not comparable to adults still living independently in the community (Cameron & Kurrle 2007). A review of literature specifically for residential settings would be needed to investigate the effectiveness of interactive technology to improve strength and balance.

Evidence-based programmes, such as FaME (Falls Management Exercise) and the Otago exercise programme, are effective programmes to improve strength and balance in older adults and reduce the risk of falling (Skelton et al. 2005). Such classes are included in the NHS Falls Care Pathways but coverage across England is patchy (Charters 2013). Due to NHS budgetary pressures there is limited funding available to invest in class provision to meet demand (The Kings Fund 2017c).

Use of interactive technology

One solution to this problem is the use of interactive technology, because it has the potential to reach a large proportion of the population at a low cost per head. For the purposes of this paper, the term 'interactive technology' refers to virtual reality gaming (also known as 'exergaming'), mobile tablets and mobile phone applications (apps). The user interacts with the technology through movement enabling them to get feedback on their physical performance.

Interactive technology can motivate older adults to be active and adhere to a regular exercise programme (Miller et al. 2014). It also offers a convenient form of exercise enabling older adults to exercise in their own home removing the barriers of joining community exercise provision (Miller et al. 2014). With activity levels declining with age (Sport England 2017), using interventions that reduce barriers to activity and increase levels of motivation are important considerations.

Use of gaming for exercise in the elderly

The use of virtual reality gaming by older adults has increased in popularity over the last decade (Laufer, Dar & Kodesh 2014; Miller et al. 2014). Research on the use of interactive technology for rehabilitation has also grown considerably during this period with more researchers investigating its potential role as a rehabilitation tool and not just for fun and recreation (Laufer et al. 2014).

Three systematic reviews have been published investigating the effects of virtual reality gaming (exergaming) on improving balance in older adults. A review by Pietrzak, Cotea & Pullman (2014) concluded there was evidence to support the use of video games to improve balance, but there was insufficient evidence to conclude falls risk was reduced. An additional systematic review by Laufer et al. (2014) also found improvements in balance in 12 out of 21 studies. However, they were not able to conclude that exergaming was effective due to inconsistencies in the quality of methodologies used. It was concluded that exergaming may be suitable to improve balance in older adults, but higher quality research was needed to inform the optimal dose of training and protocols for implementation. Zheng et al. (2019) considered seven papers looking at the effect of exergaming on physical outcomes in the frail elderly. They found that such activities can improve balance and mobility function in this sub-population.

Research on improving strength and balance together through interactive technology

An initial scoping search of the literature was undertaken to establish the current state of knowledge about the use of interactive technology to improve strength and balance simultaneously. Numerous studies were found that had researched the effects of virtual reality gaming on improving balance in older adults but very little for strength and balance combined. Only one paper was identified that included strength and balance outcomes in the same study (Choi et al. 2016). No papers were found for other types of interactive technology and their use to improve strength and balance in older adults.

Two studies have been published about the accuracy of exergaming equipment and software which supports its use as an intervention. Choi et al. (2016) developed a computer programme for the Microsoft Kinect to comprise leg strengthening exercises and balance assessment. They concluded that there was the potential for the Kinect to be a valid and reliable tool for assessing balance and being used for leg strengthening exercises. A study by Clark et al. (2010) researching the validity and reliability of the Nintendo Wii Balance Board (a type of exergame equipment) to measure standing balance concluded it was a valid and reliable tool. This research shows the potential to provide reliable measures away from a laboratory setting.

Following the above literature review, it became apparent that further research was needed. It was decided to retain the broad term ‘interactive technology’ to keep the search for knowledge as wide as possible to ensure all appropriate interventions were identified. Choosing a specific type of technology would have been too limiting for this review.

Aim and objectives

Aim: To investigate whether interactive technology can be used as an effective health intervention to improve strength and balance in community-dwelling older adults.

Objectives:

1. To systematically review the effectiveness of interactive technology to increase strength and balance in community-dwelling older adults by analysing pre- and post- measurements for leg strength and balance;

2. To make recommendations for Public Health practice and NHS interventions on the use of interactive technology to increase strength and balance as part of a multifacteted approach to reducing falls risk in community-dwelling older adults.

Methodology

Choice of approach

This research was undertaken as part of an online Master’s in Public Health degree by a sole researcher. PICO principles (Strauss et al. 2018) were used to identify the research question and search terms. PRISMA guidelines were followed to enable a thorough review. The protocol has not been published.

Search strategy

Scoping searches were carried out between 25th and 30th September 2017. This initial search of the literature highlighted a gap in published research looking at the use of interactive technology to improve strength and balance in the same intervention. The scoping searches concluded with a search of the PROSPERO database, an International prospective register of systematic reviews (https://www.crd.york.ac.uk/prospero/), on 3rd October 2017 to check for registered studies which reviewed the effects of interactive technology to improve strength and balance in older adults. No such studies were found.

To increase the chances of finding suitable papers seven online health-related databases were searched (PubMed, The Cochrane Library, Scopus, PEDro, CINHAL Plus, TRIP and NICE evidence) with a comprehensive list of search terms (Table 1). These included a broad list of types of interactive technology including commercial names to maximise the chances of finding suitable papers.

Table 1: Search terms used for database searches

Population	Intervention	Outcome
'older adults', 'geriatric', 'adult', 'over 65 years', 'old person', 'elderly', 'old age', 'independent older adults', 'community dwelling older adults'	'interactive technology', 'virtual reality gaming', 'gaming systems', 'virtual reality balance training', 'computer based exercises', 'interactive computer games', 'WiiFit', 'Nintendo Wii', 'Wii balance board', 'Microsoft Kinect', 'exergames', 'virtual trainer', 'gaming platform', 'ehealth technologies', 'ehealth technology'	'leg strength', 'hip strength', 'strength', 'balance', 'reduced falls', 'falls rate', 'risk of falls', 'falls risk', 'Berg'

Boolean search operators OR and AND were used. The publications were limited to the last five years because of advances in technology. To be able to apply the findings of this systematic review into practice, the technology still needed to be available to purchase.

Database searches were carried out between 21st and 28th October 2017 by one researcher. Results were entered into a comprehensive search table using an Excel spreadsheet to enable the searches to be repeated, if required, in future. Hand searches of reference lists were undertaken between 31st October and 11th November 2017. Secondary database searches were undertaken on 18 March 2020 to search for new papers published since November 2017. One new paper meeting the inclusion criteria was found.

Inclusion and exclusion criteria

A comprehensive list of inclusion and exclusion criteria was devised (Table 2)
Rationale for inclusion / exclusion criteria

Only papers published since 2012 were included due to advances in technology and the need to base the findings on current technology. Randomised Control Trials (RCTs) were included to base the review on high quality studies. Qualitative studies were excluded to enable findings to be based on measurable quantifiable changes rather than individual perceptions captured through qualitative methods. Studies in English only were included due to limited timescales and resources to translate papers. There was a risk this would impact on the number of final papers included if non-English language papers were excluded.

Table 2: Inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
• Papers published since 2012 • Independently living older adults (aged 65 years and over) • Older adults who have fallen • Older adults who have not fallen • Quantitative studies • Randomised Controlled Trials (RCTs) • Studies that have a control group • Studies that measure leg strength and balance at baseline and post intervention • All types of technology (exergaming, computer-based interactive technology, smart phone technology, tablet technology) • Studies on trademark names – as detailed in the search terms	• Papers published before 1st January 2012 • Older adults living in residential care homes • Condition specific research papers • All studies that are not Randomised Controlled Trials (RCTs) • Papers not written in English • Papers without a control of comparison group • Qualitative studies • Studies using frail older adults • Older adults with poor cognition • No control group • Systematic reviews • Meta-analyses • Papers that focus on children • Technology that is not interactive

Quality assessment

"The Cochrane Risk of Bias Tool for Randomised Controlled Trials" (Higgins et al. 2011) was used to screen full text papers obtained by the search strategy. This was undertaken by one researcher. The tool assessed each paper for a range of biases. These were: selection bias, reporting bias, performance bias, detection bias, attrition bias and any other potential sources of bias. Each bias category was assessed against set criteria to rate the bias as either 'low risk', 'high risk' or 'unclear risk'. The combined results were used to give each paper an overall rating for quality. The ratings were: 'Good', 'Fair' or 'Poor' quality (Higgins et al. 2011). This tool was used because it takes a thorough approach to assess multiple biases and has clear criteria to follow to enable the researcher to give each paper an overall rating.

Data extraction

Data were extracted into a form which had been created in Excel. The extraction headings were selected from the "Cochrane Public Health Group Data Extraction and Assessment Template" (The Cochrane Public Health Group 2011). The information within the Excel spreadsheet was then transferred into two tables in Word format to show the study characteristics (i.e. number of subjects, mean age, gender breakdown, intervention type, country of study and whether the study was commercially funded) and intervention details and study results (i.e. supervision, intervention duration, follow up, outcomes and key findings). One researcher undertook this exercise. The information extracted was highlighted in the full text version of the paper to make it easier for a second reviewer to check where data has been extracted from if this is required in the future.

Data analysis

The results from the full text papers were analysed to report whether or not statistically significant changes occurred between pre/post intervention measures for primary and secondary outcomes. A confidence interval range of 95% was set for each outcome measure and reported using *P* values ($p < 0.05$).

Ethics

All papers were screened to ensure they had ethical approval and obtained informed consent from participants (Weingarten, Paul & Leibovici 2004). Only research in the public domain was used and an unbiased approach taken for paper inclusion by sticking to the methodology set out before the systematic review began. Data protection laws have not been breached writing about the studies and all participant information has remained confidential (ESRC, RDI & IOE 2017).

Results

Database searches identified 592 papers. Two further papers were found from hand searching reference lists. An Excel spreadsheet was compiled to record each article title and record the databases each article was found in. This enabled 220 duplicate papers to be easily identified and removed, leaving 374 papers. Titles and abstracts of each paper were screened against the inclusion and exclusion criteria. Subsequently, 369 studies were excluded. Of the five papers remaining, full text versions were obtained for four papers (one came direct from the author after emailing to request a copy), the other paper could not be obtained (email request unsuccessful). Four full text papers were assessed for eligibility using the inclusion and exclusion criteria; all were eligible for review. Figure 1 details the study selection process.

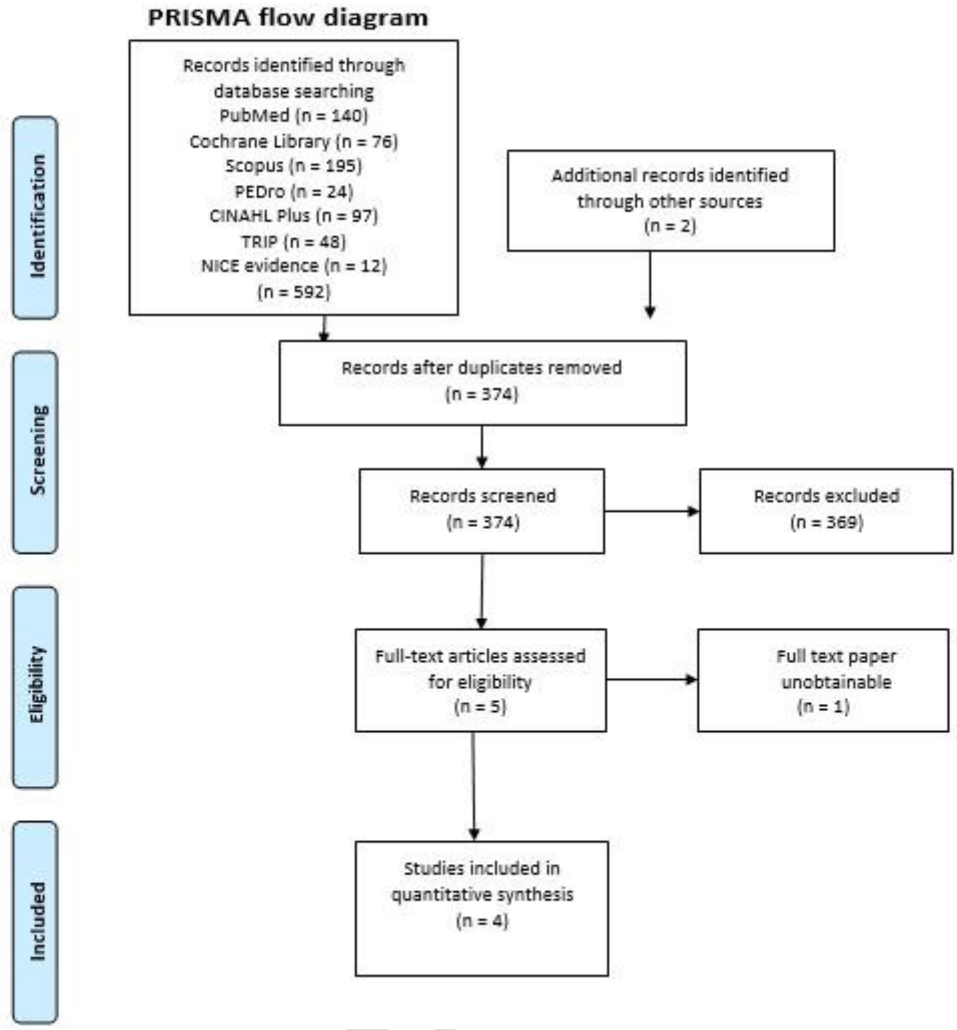

Figure 1: Flowchart of article selection process

The study characteristics, intervention details and study results are shown in Tables 3 and 4.

Table 3: Study characteristics

Study title and authors	Subjects (n)	Males / Females	Age, mean, (standard deviation), years	Intervention group type of technology used	Control group type of intervention	Country of study	Commercial research support
Effects of WiiActive exercises on fear of falling and functional outcomes in community-dwelling older adults: a randomised control trial Kwok & Pua (2016)	n = 80	12 males / 68 females	70 years (±7.1)	Nintendo WiiActive	Gym-based exercise programme	New Zealand	No
Efficacy of Nintendo Wii training on mechanical leg muscle function and postural balance in community-dwelling older adults: a randomised controlled trial Jorgensen, Laessoe, Hendriksen, Nielsen & Aagaard (2012)	n = 58	18 males / 40 females	75 years (± 6)	Nintendo Wii	Wearing shoe insoles (EVA -ethylene vinyl acetate)	Denmark	No
Improving walking, muscle strength, and balance in the elderly with an exergame using Kinect: a randomised controlled trial Sato, Kuroki, Saiki & Nagatomi (2015)	n = 57	12 males / 44 females (n = 1 Gender unknown)	69.25 years (± 5.41)	Microsoft Kinect	Going about normally daily life	Japan	No
Virtual Reality Training with Three-Dimensional Video Games Improves Postural Balance and Lower Extremity Strength in Community-Dwelling Older Adults. Lee, Choi, Lee, Song & Lee (2017)	n = 40	17 males / 23 females	76 years (± 4.55)	Nintendo Wii	Going about normally daily life	Korea	Not stated

Table 4: Intervention details and study results

Study	Supervision given	Treatment per week	Duration of intervention	Follow up	Outcomes (primary and secondary)	Key findings (CI 95%, p value < 0.05) (Key: SS ↑ = Statistically significant improvement)
Effects of WiiActive exercises on fear of falling and functional outcomes in community-dwelling older adults: a randomised control trial Kwok & Pua (2016)	Physiotherapist and therapist assistant at each session for both groups. 4 - 6 participants per session.	***Intervention group:*** 1 hour per week (40 mins Wii training, 20 mins education) ***Control group:*** 1 hour per week supervised gym-based sessions. Plus 20 mins home exercises to follow daily for both groups. No technology used. Identical exercise programme prescribed for each group.	12 weeks	Weeks 13 and 24 outcome measures captured. Falls incidence recorded monthly for one year post intervention.	**Primary outcomes:** • Fear of falling **Secondary outcomes:** • Knee extensor strength • Physical function (gait and balance) • Falls incidence 1 year post intervention • Intervention satisfaction	***<u>Intervention group:</u>*** *Primary outcomes* **Fear of Falling** SS ↑ at weeks 13 and 24 ($p < 0.001$) *Secondary outcomes* **Knee extensor strength** SS ↑ at weeks 13 and 24 ($p < 0.02$) **Physical function (gait and balance)** SS ↑ for all measurements at weeks 13 and 24 ($p < 0.01$) **Falls incidence 1 year post intervention** Reduction in falls was not statistically significant. No injurious falls reported. **Intervention satisfaction** Participants reported they were satisfied with intervention. ***<u>Control group:</u>*** *Primary outcomes* **Fear of Falling** SS ↑ at weeks 13 and 24 ($p < 0.001$) *Secondary outcomes* **Knee extensor strength** SS ↑ at weeks 13 and 24 ($p < 0.001$) **Physical function (gait and balance)** SS ↑ for all measurements at weeks 13 and 24 ($p < 0.02$) **Falls incidence 1 year post intervention** Reduction in falls was not statistically significant. No injurious falls reported. **Intervention satisfaction** Participants reported they were satisfied with intervention.

Study	Supervision given	Treatment per week	Duration of intervention	Follow up	Outcomes (primary and secondary)	Key findings **(CI 95%, p value < 0.05)** (Key: SS ↑ = Statistically significant improvement)
						Between group differences: No statistically significant differences between groups at week 13. However, at week 24 only intervention group had maintained SS improvement for reduction in fear of falling. Strength gains were greater for control group than intervention group. No significant differences between groups for satisfaction, both groups were satisfied.
Efficacy of Nintendo Wii training on mechanical leg muscle function and postural balance in community-dwelling older adults: a randomised controlled trial Jorgensen, Laessoe, Hendriksen, Nielsen & Aagaard (2012)	Physiotherapist supervising sessions (intervention group). Physiotherapist telephoned control group at 3, 6 and 9 weeks to check no problems encountered	Intervention group: 2 x per week for 35 mins (±5) per session Control group: All day, everyday	10 weeks	Not described	**Primary outcomes:** • Maximal muscle strength (legs) • Postural balance **Secondary outcomes**: • Functional performance (mobility, leg strength, fear of falling) • Motivation levels	***Pre/Post measurement differences between groups.*** ***Primary outcomes:*** **Maximal muscle strength** SS ↑ for intervention group (p = 0.001) **Postural balance** No differences within group or between groups (p = 0.92) **Secondary outcomes**: **Functional performance** • **Mobility** (TUG): Intervention group improvement was SS better than control group (p = 0.01). • **Leg strength**: (30 sec chair stand) Intervention group improvement was SS better than control group (p = 0.01). • **Fear of falling** (FES-I): Intervention group improvement was SS better than control group (p = 0.03). **Motivation levels** – at 5 weeks and 10 weeks the intervention group strongly agreed and agreed that Wii training was motivating and fun.
Improving walking, muscle strength, and balance in the elderly with an exergame using	Physical therapist, student and game development staff	Intervention group: 2 - 3 times per week for 40 mins to 1 hour until 24 sessions were completed.	8 – 12 weeks	Not described	Primary and secondary outcomes not stated in paper.	***<u>Intervention group:</u>*** **Berg Balance Test** SS ↑ for intervention group (p < 0.01) **Functional Reach test** SS ↑ for intervention group (p < 0.01)

Study	Supervision given	Treatment per week	Duration of intervention	Follow up	Outcomes (primary and secondary)	Key findings **(CI 95%, p value < 0.05)** (Key: SS ↑ = Statistically significant improvement)
Kinect: a randomised controlled trial Sato, Kuroki, Saiki & Nagatomi (2015)					Outcomes are listed by the measurement tools only: • Berg Balance Test • Functional Reach Test (FRT) • 30 second chair stand (CS-30 test) • Minimum Foot Clearance (MFC)	**30 second chair test** SS ↑ for intervention group ($p < 0.01$) SS ↑ for balance and leg strength measured by above three measurement tools. **Minimum foot clearance** No significant improvements for intervention group. ***Control group:*** No improvements across all measures.
Virtual Reality Training with Three-Dimensional Video Games Improves Postural Balance and Lower Extremity Strength in Community-Dwelling Older Adults. Lee, Choi, Lee, Song & Lee (2017)	Supervised by volunteers at venue.	***Intervention group:*** 2 x 1hour training per week Not allowed to undertake any other exercise. Falls prevention education weeks 1, 3 and 5. ***Control group:*** Not allowed to undertake any exercise. Falls prevention education weeks 1, 3 and 5.	6 weeks	Not described	Primary and secondary outcomes not specified. Outcome measures of the study were: • Static balance • Dynamic balance • Lower extremity strength	***<u>Intervention group:</u>*** ***Static balance*** SS ↑ at weeks 6 ($p < 0.05$) ***Dynamic balance (3 measures)*** Berg Balance Scale SS ↑ at weeks 6 ($p < 0.001$) Functional reach test SS ↑ at weeks 6 ($p < 0.001$) Timed up and go test SS ↑ at weeks 6 ($p < 0.001$) ***Lower extremity strength*** SS ↑ at weeks 6 ($p < 0.001$) ***<u>Control group:</u>*** ***Static balance*** No significant differences were found between baseline and week 6.) ***Dynamic balance (3 measures)*** *Berg Balance Scale* No significant differences were found between baseline and week 6. *Functional reach test*

Study	Supervision given	Treatment per week	Duration of intervention	Follow up	Outcomes (primary and secondary)	Key findings **(CI 95%, p value < 0.05)** (Key: SS ↑ = Statistically significant improvement)
						No significant differences were found between baseline and week 6. *Timed up and go test* No significant differences were found between baseline and week 6. ***Lower extremity strength*** No significant differences were found between baseline and week 6. **Between group differences:** Statistically significant differences were found between the intervention group and control group for dynamic balance ($p < 0.05$) and lower extremity strength ($p < 0.001$)

Key findings

All studies were RCTs and involved a total of 235 participants aged 65 years and over. All intervention groups used exergaming. A confidence interval of 95% was set for all studies with p values < 0.05 showing statistically significant improvements. Leg strength improved in all three studies (p <0.05). Balance improved in three studies (p <0.05) (Kwok & Pua 2016; Lee, Choi, Lee, Song & Lee 2017, Sato, Saiki & Nagatimi 2015). Balance did not improve in one study (p = 0.92) (Jorgensen, Laessoe, Hendriksen, Nielsen & Aagaard 2012).

Study characteristics

Table 3 summarises the study characteristics. The studies were conducted in New Zealand, Denmark, Japan and Korea. Ethical approval was granted for each study and informed consent obtained from all participants. None of the studies received investment of a commercial nature. All studies were RCTs using community-dwelling older adults as participants.

The type of interactive technology used in all four studies was exergaming. Three studies (Jorgensen et al. 2012; Kwok & Pua 2016; Lee et al. 2017) used the Nintendo Wii and one study (Sato et al. 2015) used the Microsoft Kinect. The studies using the Nintendo Wii used existing software that is widely available for consumers to purchase. The study by Sato et al. (2015) was trialling software for the Microsoft Kinect that had been developed by the researchers and was not available for consumers to purchase.

There were no similarities between the studies for the control groups. The intervention and control group methods were Nintendo WiiActive versus a gym-based programme (Kwok & Pua 2016); Nintendo Wii versus wearing shoe insoles (Jorgensen et al. 2012); and Microsoft Kinect versus going about normal daily life (Sato et al. 2015); Nintendo Wii versus no other exercise (Lee et al. 2017).

All four studies had a greater proportion of females to males. The mean age of the participants was similar; it was 70 years (Kwok & Pua 2016), 75 years (Jorgensen et al. 2012), 69.25 years (Sato et al. 2015) and 76 years (Lee et al. 2017). The mean age was 72.56 years (range 69.25 – 76) years. Two studies had a similar number of participants which was 58 (Sato et al. 2015) and 57 (Jorgensen et al. 2012). The study by Kwok & Pua (2016) had a larger sample size of 80. Lee et al. (2017) had the smallest number of participants with a sample size of 40.

Findings from the studies and the study characteristics are examined in detail in the 'Discussion' section of this paper.

Table 5: Quality assurance – Risk of bias

Study	Random sequence generation	Allocation concealment	Selective reporting	Other potential bias	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Cochrane Risk of Bias rating (Good / Fair / Poor quality)
Kwok & Pua (2016).	-	-	-	-	-	-	-	Good quality (7 low risk)
Jorgensen, Laessoe, Hendriksen, Nielsen, & Aagaard (2012).	-	?	-	?	-	-	-	Fair quality (5 low risk, 2 unclear)
Sato, Kuroki, Saiki, & Nagatomi (2015).	-	?	-	-	?	?	-	Poor quality (4 low risk, 3 unclear)
Lee, Choi, Lee, Song & Lee (2017).	-	?	-	-	-	-	-	Fair quality (6 low risk, 1 unclear)

Key: + = high risk of bias; ? = unclear risk of bias; - = low risk of bias.
Cochrane Collaboration's tool for assessing risk of bias in randomised trials (Higgins et al., 2011)

Quality assessment and risk of bias

Each study was quality assessed using "The Cochrane Risk of Bias Tool for Randomised Controlled Trials" (Higgins et al. 2011). Table 5 shows the level of risk for each bias for each study. Two studies were rated as good quality (Kwok & Pua 2016; Lee et al. 2017), one was fair quality (Jorgensen et al. 2012) and one was poor quality (Sato et al. 2015). The latter study was rated as poor because it had three unclear risks of bias which is due to the paper not specifying the detail for the particular risk(s).

Discussion

Study characteristics

The type of interactive technology used in all four studies was exergaming (Nintendo Wii and Microsoft Kinect). Despite broad search terms being used in the database searches no papers were found for other types of technology and therefore only findings from studies using exergaming could be reviewed. This meant this review had a narrower focus than intended to answer the research question. This did not affect the ability to answer the research question but added a limitation to the review because only one type of interactive technology could be considered. Older adults are using mobile phones, tablets and computers but their effectiveness could not be evaluated.

However, exergaming equipment such as the Nintendo Wii and Microsoft Kinect are readily available for consumers to purchase which makes them accessible interventions for older adults (subject to having the financial resources to purchase them). This means, if it was promoted as a health intervention, it would be widely available and able to reach a large proportion of the population. It is a low-cost intervention compared to exercise classes which are expensive to run and have limited spaces for participants.

Discussion of intervention details and study results

The findings reported in Table 4 are discussed in this section. Kwok & Pua (2016) reported statistically significant improvements for strength and balance outcomes for the intervention group who used the Nintendo Wii. Reducing the fear of falling was highly significant (p =0.001) and changes in leg strength and balance also showed a significant improvement (p <0.02 and p <0.01 respectively). Follow-up measures were taken at 24 weeks (12 weeks post-intervention). Improvements in strength and balance outcomes and fear of falling were sustained post intervention. One year after intervention, the authors reported the number of falls had reduced but it was not statistically significant. A p value was not reported in the study, so it is not possible to ascertain what the size of reduction was to analyse how close it was to being significant. As mentioned in the introduction, fall risk is multi-factorial so there may have been other factors affecting the falls risk such as medication, poor eyesight and trip hasards (Charters 2013). This was the largest of the four trials (n = 80) and was rated as a good quality study (when assessed for risk of bias; see Table 5) and therefore the evidence is credible to be used to base conclusions on the findings. In this study, the Nintendo Wii was effective in improving strength and balance in older adults. The control group undertook a gym-based exercise programme for the same duration as the intervention group. Statistically significant improvements were reported for fear of falling (p <0.001), leg strength (p <0.001) and balance (p <0.02). Greater strength gains were reported in the control group than the intervention group. Although gym-based training had greater strength gains compared to exergaming, this study provides evidence that exergaming is effective in improving strength and balance in older adults.

The study by Jorgensen et al. (2012) used the Nintendo Wii for the intervention group and the control group wore shoe insoles. This was to try and reduce the placebo effect and make the control group believe they were receiving an active intervention. They reported there was no evidence that the shoe insoles improved balance. The primary outcome measures for the study were maximal muscle strength and postural balance. Maximal muscle strength improvements were highly significant in the intervention group (p <0.001); however, no differences within group were reported for postural balance (p =0.92). The secondary outcome measures were only reported to show between group differences in pre- and post- intervention measures. Improvements in leg strength (30 second chair stand) were significantly better for the intervention group than the control group (p <0.01). This was also true for mobility (Timed Up and Go) where p <0.01. The reduction in fear of falling was statistically significantly better for the intervention group than the control group (p <0.03). The findings from this study show the Nintendo Wii was effective in improving strength, but not balance in older adults. Participants in the intervention group reported they found using the Nintendo Wii fun and motivating. However, there are a number of limitations that should be considered. The quality of the study was rated as fair which means caution should be applied when interpreting the results. The fair rating was given because there were two unclear risks of bias (Table 5). These were: (a) the method of concealment was not described; and (b) the contact time with the physiotherapist was greater for the intervention group than the control group which may have had a bearing on motivation levels of the control group to keep wearing their shoe insoles. These two unclear risks of bias are not deemed to have a detrimental effect on the results of the intervention group. This is because the researcher was blinded to group allocation so there would not have been a bias when collecting baseline and post-intervention data. The reduced contact time with the physiotherapist may have reduced compliance for the control group, but this would not have affected the findings from the intervention group. Based on the above, the findings of the study could be considered in the evidence for this review. However, in the study methodology it stated a minimum of 29 participants were needed in each group for the study to be powered to 80%. The intervention group only had 28 participants which meant it was slightly underpowered; therefore, the results should be treated with caution.

Sato et al. (2015) investigated new software for the Microsoft Kinect which had been designed for older adults to use. Primary and secondary outcomes were not stated in the methodology. Instead, the measurement tools were given for pre- and post-intervention. These have been interpreted as measuring balance outcomes (Berg Balance Test and Functional Reach Test) and leg strength (30 second chair test). The intervention group used the Microsoft Kinect and the control group continued with their usual daily routine. For the intervention group, statistically significant improvements were reported for balance (Berg Balance Test: p <0.01; Functional Reach Test: p <0.01) and leg strength (30 second chair test: p <0.01). No improvements were reported for the control group across all measures. The findings from this study provide evidence that the Microsoft Kinect is effective in improving strength and balance in older adults. However, the findings need to be interpreted with caution because the quality rating for the study is ‘poor’. The poor rating was given because there were three unclear risks of bias (Table 5). These were: (a) allocation concealment is not stated; (b) paper does not state whether group allocation was blinded to study staff; and (c) whether or not staff assessing participants for outcome measures pre/post intervention were blinded. If they were not, this has high risk of bias which means the results may not be true and therefore conclusions cannot be drawn from this study. Further information is required from the authors to give this study an accurate quality assurance rating. Therefore, the findings from this study could not be used to answer the research question.

The study by Lee et al. (2017) also used the Nintendo Wii to measure its effectiveness to improve lower extremity strength and static and dynamic balance. The methodology stated the outcome measures but did not distinguish between primary and secondary outcomes. The intervention group used the Nintendo Wii and the control group carried on with daily life but were instructed not to participate in any exercise activities. For the intervention group, statistically significant improvements were reported for static balance (one-leg stance test: <0.05); dynamic balance (Berg Balance Test: p <0.001; Functional Reach Test: p <0.001; Timed Up and Go: p <0.001); and lower extremity strength (30 second chair sit to stand test: p <0.001). No improvements were reported for the control group across all measures. The findings from this study provide evidence that the Nintendo Wii is effective in improving strength and balance in older adults.

The key finding from the four studies is that interactive technology was effective in improving leg strength and balance. However, the quality of the studies means that caution is needed when interpreting the findings. These findings are similar to those reported in the literature researching the effectiveness of exergaming to improve balance in older adults (Pietrzak, Cotea & Pullman 2014). Statistically significant improvements for balance were reported for studies in a systematic review by Laufer et al. (2014). However, they could not conclude that video games (exergames) were effective to improve balance in older adults due to inconsistencies and weaknesses in methodologies. This review faces similar challenges for drawing conclusions to answer the research question.

The duration of the intervention was similar for the studies; however, the overall dose varied considerably. Clinical staff supervised the intervention sessions in three out of the four studies. The total supervised training dose across the studies ranged from 12 hours to 116.6 hours. The study by Jorgensen et al. (2012) had a considerably larger dose than the other two studies (Kwok & Pua 2016; Sato et al. 2015). However, the higher dose did not appear to be associated with improved outcomes (Table 4). In fact, the study by Laessoe et al. (2012) only reported improvements for leg strength; balance did not improve. The recommended dose of at least 50 hours strength and balance training was met by only one study (Laessoe etal. (2012), the other three completed less than the 50 hours. If the trials had taken place for a longer duration (up to the recommended 6 months), all studies would have met this minimum recommended dose.

Strengths of the present study

A thorough, systematic process was followed for the search strategy which was crucial to undertake a high-quality review. The search terms were broad, and a wide range of online databases were searched. This maximised the chances of identifying all the relevant studies for consideration. This thorough approach reduced the potential for research bias and selection bias.

All included studies were RCTs which are at the top of the hierarchy of evidence. The consequences of falls for older adults are significant and it was therefore important to draw conclusions from robust evidence.

Limitations of this study

Only one type of interactive technology was considered due to a lack of published literature.

Only one researcher undertook the review. The risk of researcher bias was minimised by taking a methodological approach. A comprehensive spreadsheet was put together using Microsoft Excel to log each stage of the methodology. This can be easily followed by a second reviewer in the future if required. Recommended tools were used to assess for risk of bias and data extraction. There will always be a small risk of bias with one reviewer because individuals interpret things differently but taking a thorough, structured approach mitigates against this.

The final number of articles included in the review was small. It was limited by the lack of published research. Only four papers were included in the final selection which was a relatively small sample size from which to draw conclusions. Conclusions could only be drawn from two out of the four studies because one study was rated as poor and one slightly underpowered.

The intervention length for all studies was short and only one study captured follow up outcome measures. This limited the conclusions that could be drawn about the long-term effectiveness of the interventions to improve strength and balance and to maintain these outcomes longer term.

All studies used validated tools to measure strength and balance outcomes. However, different measures were used which meant the studies could not be directly compared to each other for effectiveness.

There may be a publication bias where studies that did not report improvements in strength and / or balance were not submitted for publication.

Implications of the review for professional practice and/or future research

This review presents the evidence to health professionals that interactive technology (in the form of exergaming) is a potential low-cost intervention to improve strength and balance in older adults. The study results show significant improvements in pre/post intervention outcome measures for strength and balance. However, the quality of the evidence is not consistently high enough on which to base recommendations for future practice. Further high-quality research is needed before recommendations can be made for Public Health practice and NHS interventions.

Conclusions

There is emerging evidence that interactive technology has the potential to be used as an effective health intervention for community-dwelling older adults. Exergaming equipment is widely available and provides a low-cost solution with the potential to reach a large proportion of the population. The results from the studies included in this review reported significant improvements in strength and balance outcomes. However, only one study (Kwok & Pua 2016) was high quality and could be used to draw conclusions for future practise. The size of the study was too small (n = 80) to be used on its own to answer the research question of this systematic review.

The value of this systematic review of the literature is that it draws attention to the emerging evidence, highlighting the limitations of research so far, hence providing recommendations for future research. The recommendations are to promote the emerging evidence to Public Health departments and to the NHS for them to consider commissioning further research in this subject area. With falls rates rising, new low-cost solutions need to be found. Interactive technology does have the potential to do this.

Further high-quality research is recommended which includes longer interventions to meet NICE guidelines (minimum dose of 50 hours over a 6-month period) and to include follow-up measures up to one year after intervention to measure the long-term effects of the training.

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