Components, design, and effectiveness of digital physical rehabilitation interventions for older people: a systematic review.

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Running head

Digital rehabilitation interventions for older adults

Article category

Systematic review

Eda Tonga[1], Cynthia Srikesavan[2], Esther Williamson[2], Sarah E Lamb[2,3]

[1]Marmara University, Faculty of Health Sciences, Department of Physiotherapy, Istanbul, Turkey

[2]Centre for Rehabilitation Research in Oxford, University of Oxford, UK

[3]University of Exeter, Collage of Medicine and Health, Exeter, UK

Correspondence information: Eda Tonga, Marmara University Faculty of Health Science, Department of Physiotherapy and Rehabilitation, MÜ. Başıbüyük Campus, Başıbüyük St. 3484, Maltepe, Istanbul, Turkey.
Email: eda.tonga@gmail.com

Declaration of interest

The authors report no declarations of interest.

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Summary

Background: With the rapid advancement in digital technologies, the use of digital health applications is increasing day by day. Although a large number of digital applications have been developed for rehabilitation of older people, there has been no review of the evidence for effectiveness of these interventions. *Methods:* The aim of our study was to review the evidence of digital rehabilitation interventions on outcomes including pain, function and quality of life in older people. We focus on digital interventions that are designed to improve and restore physical functioning. We searched six electronic bibliographic databases and included randomized controlled trials. Cochrane risk of bias tool and Cochrane's GRADE's approach were used to evaluate the risk of bias and grad the evidence. *Results:* Eight trials were included. The short-term effects of digital rehabilitation interventions on physical activity, quality of life, vertigo symptoms and falls are uncertain. Quality of trials were rated as very low to moderate evidence. *Conclusion*: More research is needed to estimate effectiveness of these interventions.

Background

The world population is aging rapidly. By 2050, it is expected that the population over the age of 60 years will have increased by 2 billion people since the beginning of 21st century [1]. The number of people over 65 in the UK today is 18% of the total population [2]. By 2030, it is estimated that this number will rise to 21.8% [1] and there will be greater demands on health and social services [3] as older people experience multiple health problems such as arthritis, diabetes, dementia and cancer [2,3] and geriatric syndromes such as frailty, falls and immobility [4,5].

There is an increased need to develop strategies that promote healthy ageing and an emerging area of interest is digital health [6]. Digital health interventions use digital-based technology to deliver accessible, usable, cost-effective, and measurable interventions to improve health, health care services, and quality of life of people or communities [7]. These technologies include to telehealth, electronic and mobile health applications (ehealth, mhealth), wearable devices and sensors, text messages, e mails. They also potentially offer increased access to treatments from home, reducing the time, physical effort and travel costs of attending appointments [6].

Technology-assisted health care systems generally focus on specific population groups, such as older people and patients with chronic diseases [8]. Common interventions include self-monitoring and management of chronic diseases, patient education medication reviews, promotion of physical activity and exercise, healthy eating and cognitive behavioural therapies [9].

In this review, we focus on digital physical rehabilitation interventions that are designed to improve and restore physical functioning in older people. There are different ways to deliver digital rehabilitation interventions and options include desktop computers, laptops, tablets, smartphones and their additional sensor systems [7].

Taking part in regular physical activity (PA) and exercise is important for older people to maintain or improve the physical function needed to live independently and main good health [10]. Home exercise programs are often a fundamental part of successful rehabilitation for older people [11]. However, the

adherence to home exercise programs is often low [11] and older people are more likely to adhere to supervised exercises programmes [12]. Digital interventions have the potential to support older people by providing clinicians with a means of encouraging and motivating patients to undertake exercise and self-management strategies [6, 11].

To date, there is only one systematic review of digital interventions in this area, and the study is limited to tele-health to support self-management in older people with chronic disease [13]. However, there is no review available on the effectiveness of rehabilitation interventions delivered via digital routes in older people.

Objectives

To summarise the evidence on the benefits and harms of digital rehabilitation interventions on outcomes including pain, function and quality of life in older people.

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a) Studies:

Randomized controlled trials that evaluated the effectiveness of digital rehabilitation interventions specifically designed for older people.

Qualitative studies that reported the patient experience of these interventions. Only peer-reviewed publications in English language were considered. Conference abstracts, dissertations and articles published in other languages were.

b) Population: Men and women above 60 years of age with any chronic physical health condition including falls or mobility problems.

c) Intervention: Self-directed digital rehabilitation interventions focusing on physical health delivered via web-based, online platform, mobile applications were included. Digital rehabilitation interventions delivered by health professionals in clinical settings and those used solely for data collection or self-monitoring (e.g. physical activity data collected from a wearable sensor) were excluded.

d) Comparator: The control groups could be either receiving usual care, no treatment, a placebo (a digital rehabilitation intervention with limited features) or a non-digital rehabilitation intervention.

e) Outcomes: The main outcomes include pain, physical activity, function including mobility and fall related outcomes, quality of life, adverse events, and health resource use. Other outcomes of interest were psychological outcomes including self-efficacy, fear avoidance, anxiety, and depression, and process outcomes such as intervention adherence rate and user perspectives.

f) Timing: Outcomes were categorized into short-term (up to 3 months), medium-term (>3 to 11 months) and long-term (12 months and beyond).

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We developed a search strategy (Supplementary file 1) in consultation with a health sciences librarian at the University of Oxford. The strategy was adapted for each bibliographic database. We used simple key words to search the JMIR and the trial databases.

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Two review authors (ET and CS) independently screened the titles and abstracts to identify potential studies from the database searches. ET and CS then screened the full-text publications of the potential studies based on the predefined eligibility criteria of the review. The reasons for excluding studies were documented. ET and CS consulted a third review author (EW) to resolve any disagreements during the study selection process.

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Summary measures

We proposed to calculate the treatment estimates as mean difference or standardised mean difference for continuous outcomes and risk ratio for dichotomous outcomes with 95% confidence interval at short, medium and long-term.

Synthesis of results

Before undertaking this review, it was unknown if it would be possible to carry out meta-analysis. Therefore, we specified statistical heterogeneity I^2 at 75% as cut point to determine that meta-analysis was not appropriate. The clinical heterogeneity was judged by the review authors based on the similarities and differences between participants, interventions and the outcome measures used in the included studies.

Grading of evidence

We used the Cochrane's Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach [15, 16] to evaluate the quality of evidence as high, moderate, low or very low for the main outcomes of the review.

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Study Selection

Figure 1 shows the study selection process. A total of 35,835 records were identified from the database searches (16,366 from Medline, 15,361 from EMBASE, 3623 from CINAHL, and 454 from PEDro). Additional records were identified by searching the Journal of Medical Internet Research (JMIR) journal and its PubMed indexed sister journals. After screening full-text articles, 8 trials [10, 17-23] were determined eligible for our review. One trial was reported in two publications [18-19]. Therefore, a total of seven trials were included.

We did not identify any qualitative studies that explored older peoples' experience of digital rehabilitation interventions.

Study Characteristics

Of the seven trials, five trials focused on increasing physical activity [10, 17-19, 22-23]. One trial included a vestibular rehabilitation programme for dizziness [20], and the other evaluated a falls prevention programme [21]. The interventions were delivered via a tablet in two trials [17, 21], web connected pedometer in two trials [17, 23], accelerometer in one trial [18]. One trial used a combination of virtual animation coach and computer games with Kinect sensor [17]

The characteristics of the included trials are shown in Table 1. Three trials were from the United States of America [10, 17, 23]; two from Europe [18-19, 22]; and one each from Australia [21] and the United Kingdom [20]. The sample size ranged from 102 to 415. Three trials provided no intervention to those in the control arm [10, 22, and 23]. Two trials delivered usual care/education [17, 20, and 21] and one trial used a wait list control [18-19]. The duration of digital rehabilitation interventions ranged from 6 weeks to 4 months. The components of the interventions were mapped to the Behavioural Intervention Technology (BIT) model and presented in Table 2.

The most commonly evaluated outcome was physical activity [10, 17-19, 22-23], followed by quality of life [10, 18-19]. Other outcomes included disability or function (two trials), adverse events (two trials), fall risk (one trial), vestibular symptoms (one trial), psychological measures (2 trials), user perspective (three trials), and intervention adherence (two trials). All trials reported short-term follow-

up results. The medium-term long-term effects were reported in one trial each. The medium-term was reported in one trial [10] and long-term effects in two trials 17, 22].

Methodological Quality

The bias assessment of the included trials is shown in Table 3. The overall risk of bias was rated as unclear for two trials [20, 22] and high risk for 5 trials [10, 17-19, 23]. The high risk of bias was due to lack of blinding of participants and personnel delivering the interventions. Trials were predominantly rated as high risk of bias due to lack of blinding of participants and personnel delivering the interventions. Assessing outcomes were blinded in five of seven studies. While one study was conducted with over 400 participants, the number of participants ranged from 102 to 263 in other studies. Participants were recruited via online requirement strategies (eg, social media, websites, emails, newsletters) in four studies [10,18,19,22,23]. iStoppFalls study was carried out multicenter requirement. One trial was single centered [20] and other study were required the adults from three outpatient clinics[17].

Outcomes

We concluded that data could not be pooled due to heterogeneous nature of the participants, interventions and outcome measures. Therefore, a narrative summary of the effects of digital rehabilitation interventions on the outcomes is presented (Tables 4 and 5).

Physical activity

Pedometer, accelerometer and the International Physical Activity Questionnaire (IPAQ) were used to assess physical activity in five trials (Table 3). It appears that web-based interventions do increase physical activity in short/medium term with all studies reporting improvements compared to the control intervention. Two studies found that web based PA interventions is effective for increasing step count in the short term [17, 23]. Irvene et.al [10] reported that web-based PA interventions are effective in both the short and medium term at increasing the time being physically active by evaluating the total minute physical activity for a week in cardiovascular activities, stretching activities, strengthening activities, balance [10].

No difference was observed in outcomes at 12 months.

Quality of life

Three trials evaluated quality of life. Two of these were physical activity interventions [10,19] . One trial reported significant effects favouring digital rehabilitation interventions in the short and medium term (Irvine). Broekhuizen [19] only reported a significant improvement for emotional-mental subscale score of the Research and Development 36 item Health Survey/ RAND 36. There were no significant difference in quality of life for digital vestibular training in short term [21].

Vestibular and Fall Risk Outcomes

Digital-based vestibular training was found effective in both short and medium term for vertigo symptoms [20]. One trial focused on fall risk and reported that digital rehabilitation reduces the physiological fall risk [21].

Disability

The impact of digital rehabilitation interventions on disability/function was reported in two trials. One trial that evaluated a balance retraining programme [20] found a significant reduction in dizziness related disability using the Dizziness Handicap Inventory compare to control group. Another trial on a falls prevention programme [21] measured general health (including mobility, activities, participation, and self-care) using the World Health Organisation Disability Assessment Schedule (WHODAS) 2. No significant difference was found between the intervention and control groups.

Adverse events

Only two trials reported adverse events. The iStoppFall study reported that there were no adverse events in the study [21]. Bickmore et al [17] reported 289 adverse events of which 10 were moderate-severe events that were likely be not related to digital intervention (8 in control 2 in intervention group) [17].

Pain

None of the included trials evaluated this outcome.

Health resource use

None of the included trials evaluated this outcome.

Psychological outcomes

Anxiety

Gearagty et. al [20] found a greater reduction in anxiety at 3 months in intervention group measured by the HADS (Hospital Anxiety and Depression Scale) compared to the control, but this difference was not sustained at 6 months.

Depression

Digital vestibular rehabilitation intervention had no significant effect on depression at three or six months compared to the control intervention [20]. Similarly, the iStoppFalls study reported no significant difference in a measure of depression between intervention and usual care groups study [21].

Self-efficacy

None of the included trials evaluated this outcome.

Fear avoidance

None of the included trials evaluated this outcome.

Process outcomes

Intervention adherence

Only 2 trials reported data on intervention adherence which was determined by number of times they accessed the web based intervention or completion rates of the programme. Bickmore et al [17] reported that the embodied conversational agent-based PA intervention participants interacted with the virtual coach at an average of 35±19 times during the 2-month intervention. Wishman et al determined that 91.2% of participants completed the web-based program [18]. None of the studies used the adherence to digital intervention as a primary assessment measure and did not evaluate the adherence by a patient reported scale or questionnaires. In other words, the evaluations and results related to intervention adherence in the studies are insufficient. Therefore, it is not possible to conclude about intervention adherence with limited findings.

Intervention Attrition

Two studies that compare the efficacy of an online PA intervention reported small dropout rates (Bickmore, et al= 3%, Broekhuizen,et al. =6.7%) for intervention attrition. One study which assessed the effectiveness web-based fall prevention program has similar dropout rates between intervention and control group (n=52, 15 drop out from intervention group, 13 dropouts from control group). Two studies reported high level of intervention attrition rates. Irvene et. al reported that 36.5% participants didn't completed the all sessions. Besides, a study that compare the effectiveness of an online vestibular rehabilitation reported high attrition as 23% [21].

User perspectives

User satisfaction were evaluated in two trials. [10, 17]. Both trials used a Likert scale (1 to 7) to measure participants' satisfaction, and Both of them reported an average score of 6 (quite satisfied). In Irvene et al [10], participants also rated the program as very easy to use and very helpful, and, they would recommend the program to friends or family (7-point scale, mean=5.7±1.4).

Quality of Evidence

The quality of evidence for the main outcomes of the review are presented in Table 6.

Physical activity

In the short term, digital rehabilitation interventions may improve physical activity in older adults compared to no intervention or waiting list but the evidence is of moderate quality. It is uncertain whether they are effective compared to a pedometer only intervention as although results favour the digital intervention it is based on very low quality evidence.

In the medium term, digital rehabilitation interventions probably improve physical activity compared to no intervention (Moderate evidence).

In the long term, it is uncertain whether digital rehabilitation interventions have no effect compared to no intervention or a pedometer-based intervention as this based on one study and the evidence is very low quality evidence.

Quality of life

In the short term, it is uncertain whether digital rehabilitation interventions have or do not have an effect on the QoL-physical domain compared to no intervention or waiting list due to inconsistent findings based on very low quality evidence. They may slightly improve QoL-mental domain compared to no intervention or waiting list (Low quality evidence). It is uncertain whether digital rehabilitation interventions have no effect on the overall QoL, compared to education only due to very low quality evidence.

In the medium term, digital rehabilitation interventions probably improve individual physical and mental domains compared to no intervention (Moderate evidence).

Vertigo symptoms

In the short and medium term, it is uncertain whether digital rehabilitation interventions are effective in improving vertigo symptoms than the usual care as although results favours the digital intervention it is based on very low quality evidence.

Falls risk

In the short-term, it is uncertain whether digital rehabilitation interventions are effective in reducing falls risk than a falls prevention education programme as although results favours the digital intervention it is based on very low quality evidence.

Discussion

This review evaluated the effectiveness and safety of digital rehabilitation interventions in people over 60 years of age. We included seven randomized controlled trials to this review. These trials compared digital rehabilitation interventions that focused on physical activity, falls prevention and vestibular retraining to a range of control interventions (usual care, education, no intervention or waiting list). The findings suggest that digital health interventions may improve physical activity and quality of life in the medium term (Moderate evidence). However, there is inconclusive evidence for the short-term effects on physical activity, quality of life (physical and mental domains), vertigo symptoms and falls risk due to risk of bias, indirectness of evidence, and small sample sizes. There was a lack of consistency on the effects on quality of life. The long term effects on physical activity is unknown. Further research has the potential to change these findings. Only 2 studies included long term follow up and no difference between interventions was observed.

Secondary outcomes of interest that were studied included anxiety, depression, satisfaction, adherence, and trial attrition. None of the included trials evaluated health resource use outcomes, pain, and self-efficacy or fear avoidance behavior. There were very few adverse events reported that are likely to be related to the interventions but only 2 trials actually reported adverse events so the safety profile of this type of intervention is unclear.

A range of methods were used by the studies in this review. Only 2 trials measured satisfaction with the interventions but both suggested that these were acceptable interventions for older people and engagement was good. A recent systematic review concluded that tablet technology is acceptable and satisfying to older people, even if they have cognitive disorders [29]. Acceptability of digital rehabilitation interventions to older people is important if we want older people to access care in this way. Notably there were no trials in this review using Smartphone which are in very common use, although, we are aware of a feasibility trial that is underway in the UK to evaluate an intervention delivered via Smartphone technology to support home exercises and prevent falls [31] .

The majority of trials in this review focused on increasing physical activity [10, 17, 18, 19, 22, and 23]. Physical activity is a key target for health improvement or disease prevention in in older people. Prior systematic reviews specified that population-based strategies with the use of e-health to promote PA are effective [27]. Our findings would suggest there is also potential to improve physical activity as a rehabilitation strategy using digital rehabilitation interventions. All the interventions required participants to interact with the digital application on a daily or weekly basis. Mouton and Irvene noted that engagement with the programme was better when the programme was supervised.

The prevention of falls is another treatment target to improve health outcomes in older people. Nearly one in three older people aged over 65 experience a fall at least once a year and results in a large social and economic burden on individuals, and health services. Exercise is an effective strategy for preventing falls and digital rehabilitation interventions have the potential to make this type of treatment accessible to large numbers of older people [5]. There was only one trial included in this review that focused on balance training [21]. And it utilized game technology to deliver balance and strengthening exercises, a feature distinguishing it from other studies in this review. However, the system used in this trial contained a lot of additional technologies such as Kinect sensor systems, accelerometer, Google TV set, and computers/tablets. The digital fall-stop intervention program reduced the physiological fall risk for older people, but further research is needed including testing more simple technologies which would make the intervention more accessible. The final trial in this review focused on vestibular rehabilitation and resulted in reduced dizziness and disability compared to the control [20]. Demonstrating that this type of intervention can successfully be delivered using a digital approach overcoming economic barriers and increasing accessibility [20]. In all studies, the control groups were 'usual care' or 'no treatment'. Although this had been noted as BIAS for comparators, the comparison of the included studies has been consistent since all studies are similar.

Limitations

The review focused on physical rehabilitation interventions for older people delivered using digital platforms. This meant we excluded studies that used for tele-rehabilitation (telephone calls or messaging) which appeared to be more common in the literature and therefore resulted in a small number of studies. Although, 5 of the seven trials focused on physical activity, we were unable perform meta-analysis because of heterogeneity in the included studies. It was not possible to blind participants and personnel to the intervention received by participants so all studies were considered high risk for this element of the risk of bias assessment making it impossible for studies to be considered low risk of bias according to the Cochrane risk of bias tool.

Conclusions

Digital rehabilitation interventions seem to have potential to benefit older people in improving physical activity and quality of life in the medium term. However, there is uncertainty around the short-term effects on physical activity, quality of life (physical and mental domains), vertigo symptoms and falls. More research is needed to establish robust estimates of effectiveness including long-term outcomes. There is a need to conduct large trials that include evaluation of cost-effectiveness and safety of these interventions for older people.

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Summary

Background: With the rapid advancement in digital technologies, the use of digital health applications is increasing day by day. Although a large number of digital applications have been developed for rehabilitation of older people, there has been no review of the evidence for effectiveness of these interventions. *Methods:* The aim of our study was to review the evidence of digital rehabilitation interventions on outcomes including pain, function and quality of life in older people. We focus on digital interventions that are designed to improve and restore physical functioning. We searched six electronic bibliographic databases and included randomized controlled trials. Cochrane risk of bias tool and Cochrane's GRADE's approach were used to evaluate the risk of bias and grad the evidence. *Results:* Eight trials were included. The short-term effects of digital rehabilitation interventions on physical activity, quality of life, vertigo symptoms and falls are uncertain. Quality of trials were rated as very low to moderate evidence. *Conclusion*: More research is needed to estimate effectiveness of these interventions.

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Of the seven trials, five trials focused on increasing physical activity [10, 17-19, 22-23]. One trial included a vestibular rehabilitation programme for dizziness [20], and the other evaluated a falls prevention programme [21]. The interventions were delivered via a tablet in two trials [17, 21], web connected pedometer in two trials [17, 23], accelerometer in one trial [18]. One trial used a combination of virtual animation coach and computer games with Kinect sensor [17]

The characteristics of the included trials are shown in Table 1. Three trials were from the United States of America [10, 17, 23]; two from Europe [18-19, 22]; and one each from Australia [21] and the United Kingdom [20]. The sample size ranged from 102 to 415. Three trials provided no intervention to those in the control arm [10, 22, and 23]. Two trials delivered usual care/education [17, 20, and 21] and one trial used a wait list control [18-19]. The duration of digital rehabilitation interventions ranged from 6 weeks to 4 months. The components of the interventions were mapped to the Behavioural Intervention Technology (BIT) model and presented in Table 2.

The most commonly evaluated outcome was physical activity [10, 17-19, 22-23], followed by quality of life [10, 18-19]. Other outcomes included disability or function (two trials), adverse events (two trials), fall risk (one trial), vestibular symptoms (one trial), psychological measures (2 trials), user perspective (three trials), and intervention adherence (two trials). All trials reported short-term follow-

up results. The medium-term long-term effects were reported in one trial each. The medium-term was reported in one trial [10] and long-term effects in two trials 17, 22].

Methodological Quality

The bias assessment of the included trials is shown in Table 3. The overall risk of bias was rated as unclear for two trials [20, 22] and high risk for 5 trials [10, 17-19, 23]. The high risk of bias was due to lack of blinding of participants and personnel delivering the interventions. Trials were predominantly rated as high risk of bias due to lack of blinding of participants and personnel delivering the interventions. Assessing outcomes were blinded in five of seven studies. While one study was conducted with over 400 participants, the number of participants ranged from 102 to 263 in other studies. Participants were recruited via online requirement strategies (eg, social media, websites, emails, newsletters) in four studies [10,18,19,22,23]. iStoppFalls study was carried out multicenter requirement. One trial was single centered [20] and other study were required the adults from three outpatient clinics[17].

Outcomes

We concluded that data could not be pooled due to heterogeneous nature of the participants, interventions and outcome measures. Therefore, a narrative summary of the effects of digital rehabilitation interventions on the outcomes is presented (Tables 4 and 5).

Physical activity

Pedometer, accelerometer and the International Physical Activity Questionnaire (IPAQ) were used to assess physical activity in five trials (Table 3). It appears that web-based interventions do increase physical activity in short/medium term with all studies reporting improvements compared to the control intervention. Two studies found that web based PA interventions is effective for increasing step count in the short term [17, 23]. Irvene et.al [10] reported that web-based PA interventions are effective in both the short and medium term at increasing the time being physically active by evaluating the total minute physical activity for a week in cardiovascular activities, stretching activities, strengthening activities, balance [10].

No difference was observed in outcomes at 12 months.

Quality of life

Three trials evaluated quality of life. Two of these were physical activity interventions [10,19] . One trial reported significant effects favouring digital rehabilitation interventions in the short and medium term (Irvine). Broekhuizen [19] only reported a significant improvement for emotional-mental subscale score of the Research and Development 36 item Health Survey/ RAND 36. There were no significant difference in quality of life for digital vestibular training in short term [21].

Vestibular and Fall Risk Outcomes

Digital-based vestibular training was found effective in both short and medium term for vertigo symptoms [20]. One trial focused on fall risk and reported that digital rehabilitation reduces the physiological fall risk [21].

Disability

The impact of digital rehabilitation interventions on disability/function was reported in two trials. One trial that evaluated a balance retraining programme [20] found a significant reduction in dizziness related disability using the Dizziness Handicap Inventory compare to control group. Another trial on a falls prevention programme [21] measured general health (including mobility, activities, participation, and self-care) using the World Health Organisation Disability Assessment Schedule (WHODAS) 2. No significant difference was found between the intervention and control groups.

Adverse events

Only two trials reported adverse events. The iStoppFall study reported that there were no adverse events in the study [21]. Bickmore et al [17] reported 289 adverse events of which 10 were moderate-severe events that were likely be not related to digital intervention (8 in control 2 in intervention group) [17].

Pain

None of the included trials evaluated this outcome.

Health resource use

None of the included trials evaluated this outcome.

Psychological outcomes

Anxiety

Gearagty et. al [20] found a greater reduction in anxiety at 3 months in intervention group measured by the HADS (Hospital Anxiety and Depression Scale) compared to the control, but this difference was not sustained at 6 months.

Depression
Digital vestibular rehabilitation intervention had no significant effect on depression at three or six months compared to the control intervention [20]. Similarly, the iStoppFalls study reported no significant difference in a measure of depression between intervention and usual care groups study [21].

Self-efficacy
None of the included trials evaluated this outcome.

Fear avoidance
None of the included trials evaluated this outcome.

Process outcomes

Intervention adherence

Only 2 trials reported data on intervention adherence which was determined by number of times they accessed the web based intervention or completion rates of the programme. Bickmore et al [17] reported that the embodied conversational agent-based PA intervention participants interacted with the virtual coach at an average of 35±19 times during the 2-month intervention. Wishman et al determined that 91.2% of participants completed the web-based program [18]. None of the studies used the adherence to digital intervention as a primary assessment measure and did not evaluate the adherence by a patient reported scale or questionnaires. In other words, the evaluations and results related to intervention adherence in the studies are insufficient. Therefore, it is not possible to conclude about intervention adherence with limited findings.

Intervention Attrition

Two studies that compare the efficacy of an online PA intervention reported small dropout rates (Bickmore, et al= 3%, Broekhuizen,et al. =6.7%) for intervention attrition. One study which assessed the effectiveness web-based fall prevention program has similar dropout rates between intervention and control group (n=52, 15 drop out from intervention group, 13 dropouts from control group). Two studies reported high level of intervention attrition rates. Irvene et. al reported that 36.5% participants didn't completed the all sessions. Besides, a study that compare the effectiveness of an online vestibular rehabilitation reported high attrition as 23% [21].

User perspectives

User satisfaction were evaluated in two trials. [10, 17]. Both trials used a Likert scale (1 to 7) to measure participants' satisfaction, and Both of them reported an average score of 6 (quite satisfied). In Irvene et al [10], participants also rated the program as very easy to use and very helpful, and, they would recommend the program to friends or family (7-point scale, mean=5.7±1.4).

Quality of Evidence

The quality of evidence for the main outcomes of the review are presented in Table 6.

Physical activity

In the short term, digital rehabilitation interventions may improve physical activity in older adults compared to no intervention or waiting list but the evidence is of moderate quality. It is uncertain whether they are effective compared to a pedometer only intervention as although results favour the digital intervention it is based on very low quality evidence.

In the medium term, digital rehabilitation interventions probably improve physical activity compared to no intervention (Moderate evidence).

In the long term, it is uncertain whether digital rehabilitation interventions have no effect compared to no intervention or a pedometer-based intervention as this based on one study and the evidence is very low quality evidence.

Quality of life

In the short term, it is uncertain whether digital rehabilitation interventions have or do not have an effect on the QoL-physical domain compared to no intervention or waiting list due to inconsistent findings based on very low quality evidence. They may slightly improve QoL-mental domain compared to no intervention or waiting list (Low quality evidence). It is uncertain whether digital rehabilitation interventions have no effect on the overall QoL, compared to education only due to very low quality evidence.

In the medium term, digital rehabilitation interventions probably improve individual physical and mental domains compared to no intervention (Moderate evidence).

Vertigo symptoms

In the short and medium term, it is uncertain whether digital rehabilitation interventions are effective in improving vertigo symptoms than the usual care as although results favours the digital intervention it is based on very low quality evidence.

Falls risk

In the short-term, it is uncertain whether digital rehabilitation interventions are effective in reducing falls risk than a falls prevention education programme as although results favours the digital intervention it is based on very low quality evidence.

Discussion

This review evaluated the effectiveness and safety of digital rehabilitation interventions in people over 60 years of age. We included seven randomized controlled trials to this review. These trials compared digital rehabilitation interventions that focused on physical activity, falls prevention and vestibular retraining to a range of control interventions (usual care, education, no intervention or waiting list). The findings suggest that digital health interventions may improve physical activity and quality of life in the medium term (Moderate evidence). However, there is inconclusive evidence for the short-term effects on physical activity, quality of life (physical and mental domains), vertigo symptoms and falls risk due to risk of bias, indirectness of evidence, and small sample sizes. There was a lack of consistency on the effects on quality of life. The long term effects on physical activity is unknown. Further research has the potential to change these findings. Only 2 studies included long term follow up and no difference between interventions was observed.

Secondary outcomes of interest that were studied included anxiety, depression, satisfaction, adherence, and trial attrition. None of the included trials evaluated health resource use outcomes, pain, and self-efficacy or fear avoidance behavior. There were very few adverse events reported that are likely to be related to the interventions but only 2 trials actually reported adverse events so the safety profile of this type of intervention is unclear.

A range of methods were used by the studies in this review. Only 2 trials measured satisfaction with the interventions but both suggested that these were acceptable interventions for older people and engagement was good. A recent systematic review concluded that tablet technology is acceptable and satisfying to older people, even if they have cognitive disorders [29]. Acceptability of digital rehabilitation interventions to older people is important if we want older people to access care in this way. Notably there were no trials in this review using Smartphone which are in very common use, although, we are aware of a feasibility trial that is underway in the UK to evaluate an intervention delivered via Smartphone technology to support home exercises and prevent falls [31] .

The majority of trials in this review focused on increasing physical activity [10, 17, 18, 19, 22, and 23]. Physical activity is a key target for health improvement or disease prevention in in older people. Prior systematic reviews specified that population-based strategies with the use of e-health to promote PA are effective [27]. Our findings would suggest there is also potential to improve physical activity as a rehabilitation strategy using digital rehabilitation interventions. All the interventions required participants to interact with the digital application on a daily or weekly basis. Mouton and Irvene noted that engagement with the programme was better when the programme was supervised.

The prevention of falls is another treatment target to improve health outcomes in older people. Nearly one in three older people aged over 65 experience a fall at least once a year and results in a large social and economic burden on individuals, and health services. Exercise is an effective strategy for preventing falls and digital rehabilitation interventions have the potential to make this type of treatment accessible to large numbers of older people [5]. There was only one trial included in this review that focused on balance training [21]. And it utilized game technology to deliver balance and strengthening exercises, a feature distinguishing it from other studies in this review. However, the system used in this trial contained a lot of additional technologies such as Kinect sensor systems, accelerometer, Google TV set, and computers/tablets. The digital fall-stop intervention program reduced the physiological fall risk for older people, but further research is needed including testing more simple technologies which would make the intervention more accessible. The final trial in this review focused on vestibular rehabilitation and resulted in reduced dizziness and disability compared to the control [20]. Demonstrating that this type of intervention can successfully be delivered using a digital approach overcoming economic barriers and increasing accessibility [20]. In all studies, the control groups were 'usual care' or 'no treatment'. Although this had been noted as BIAS for comparators, the comparison of the included studies has been consistent since all studies are similar.

Limitations

The review focused on physical rehabilitation interventions for older people delivered using digital platforms. This meant we excluded studies that used for tele-rehabilitation (telephone calls or messaging) which appeared to be more common in the literature and therefore resulted in a small number of studies. Although, 5 of the seven trials focused on physical activity, we were unable perform meta-analysis because of heterogeneity in the included studies. It was not possible to blind participants and personnel to the intervention received by participants so all studies were considered high risk for this element of the risk of bias assessment making it impossible for studies to be considered low risk of bias according to the Cochrane risk of bias tool.

Conclusions

Digital rehabilitation interventions seem to have potential to benefit older people in improving physical activity and quality of life in the medium term. However, there is uncertainty around the short-term effects on physical activity, quality of life (physical and mental domains), vertigo symptoms and falls. More research is needed to establish robust estimates of effectiveness including long-term outcomes. There is a need to conduct large trials that include evaluation of cost-effectiveness and safety of these interventions for older people.

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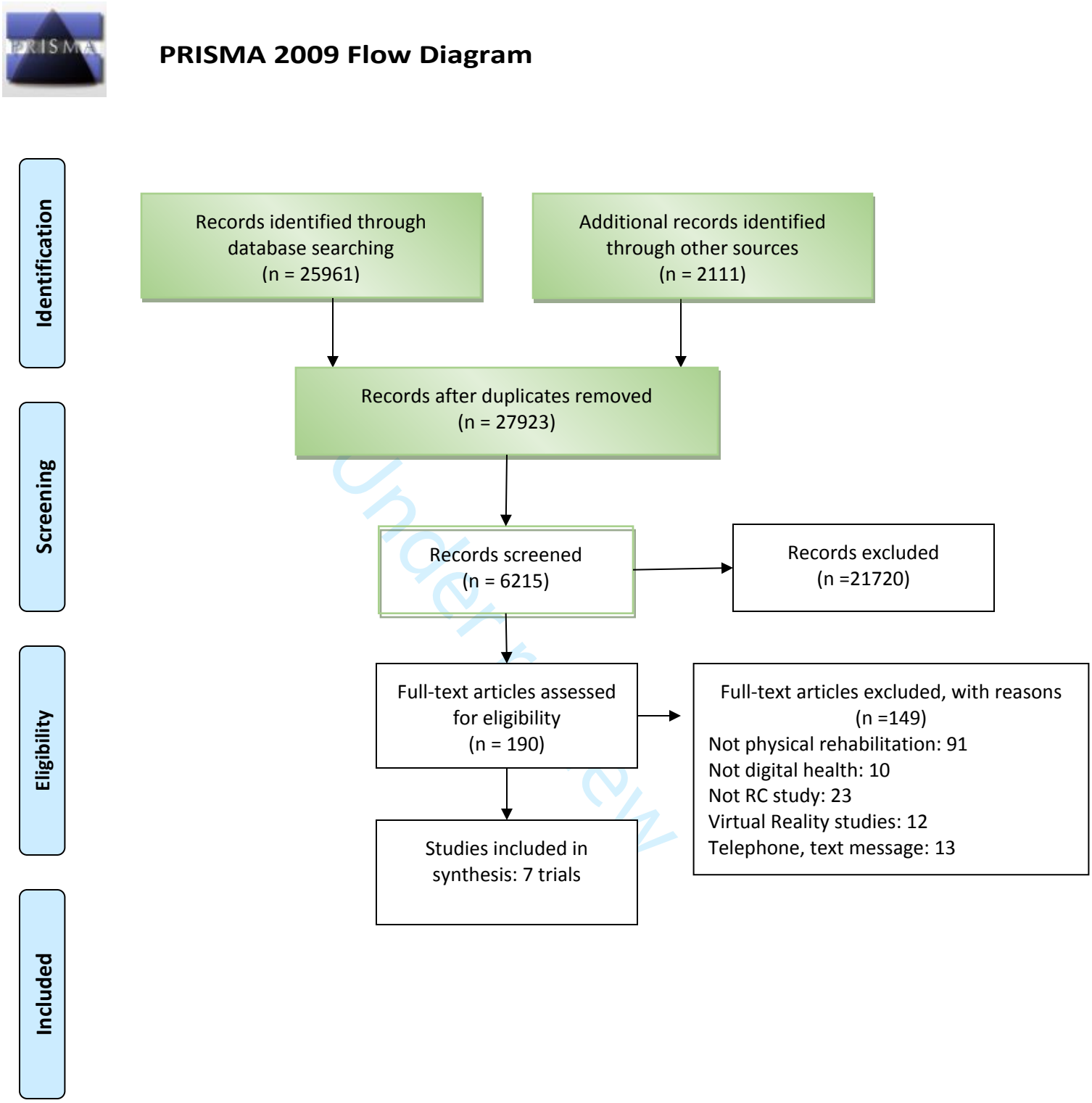

Figure 1

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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Table 1. Characteristics of the included trials.

Author & Year Country	Randomised (N) Mean age in years Gender %	Key eligibility criteria	Outcomes relevant to the review	Control intervention	Digital rehabilitation intervention	Duration
Irvine 2013 [10] United States	405 60.3 years 69.4% females	Inclusion: Aged above 55 years with no more 60 min/week moderate exercise	Physical activity; Quality of life; User satisfaction; Barriers to exercise	No intervention	Active After 55: Personalised physical activity programme. 11 weekly sessions, 10-15 minutes each.	3 months
Bickmore, 2013 [17] United States	263 71.3 years 61.2% females	Inclusion: Aged 65 year and over, inactive, stable medical condition Exclusion: Cognitive and depressive symptoms, high risk of fall risk.	Physical activity; Adverse events; Treatment satisfaction	Pedometers were worn and steps were monitored.	Tablet computers connected with pedometers to deliver an embodied conversational agent (animated characters) based physical activity intervention.	2 months
Wijsman 2013 [18] & Broekhuizen 2016 [19] Netherlands	235 65 years 41% females	Inclusion: Inactive, no Diabetes, no glucose-lowering medication, no disability impeding physical activity.	Physical Activity; Quality of life	Waiting list	Direct Life physical activity programme: Included an accelerometer-based activity monitor, a website, and a personal-coach to monitor and provide tips via email.	3 months
Geraghty 2017 [20] United Kingdom	296 67 years 67% females	Inclusion: 50 years and above, dizziness over 2 years , have internet access Exclusion: Medical contraindications, e.g. serious co-morbidity	Dizziness related disability; Depression	Usual care - education, reassurance, medication for nausea.	Balance retraining: Fully automated online programme. 6 sessions with vestibular exercises and coping strategies.	1.5 months
Gschwind 2015 [21] Australia	153 74.7 years 61.2% females	Inclusion: Aged 65 years and above, able to walk 20 metres unaided and watch television from 3 metres. Exclusion: Language problems, cognitive impairment, medical conditions limiting participation.	General health; Depression; Balance ; Adverse events; Adherence; Falls efficacy ; User experience	Evidence-based educational booklet on healthy lifestyle and fall prevention.	iStoppFalls: An Information and Communication based system for assessing fall risks and preventing falls in older people.	4 months
Mouton 2015 Belgium [22]	102 Intervention: 61.2 years Control: 66.1 years Intervention: 39.6% males Control: 38.3% males	Inclusion: 50 years and above, French language, access to Internet.	Physical activity; User Satisfaction	No intervention	Move More: The web-based programme covered benefits of physical activity, success stories, exercises, overcoming barriers, and tailored feedback.	3 months
Rowley 2017 [23] United States	108 Intervention: 67.4 years Control: 66.1 years Intervention: 81.3% females Control: 78.6% females	Inclusion: Inactive adults, no limitations to walking, access to computer.	Physical activity	No intervention	Tailored, internet pedometer-based programme to reach 10000 steps per day and maintain afterward.	3 months

Table 2. The Behavioural Intervention Technology (BIT) Model mapped to digital rehabilitation interventions in older adults.

Digital rehabilitation intervention	Aims	Behavioural change strategies	Elements	Characteristics	Workflow
Active After 55: Internet based physical activity programme [10]	To promote function and mobility in older adults. Adopts a self-tailored approach based on theory of planned behaviour.	Goal setting; Self-tailored exercise planning/Ownership; Barrier identification; Review of progress; Knowledge on exercise benefits; Encouragement	Success stories; Library for more articles; Safety tips; Disease specific recommendations	*Medium:* A narrator and personal coach presented text and video messages *Complexity:* Grade 6-8 reading level; Bullet text points; New exercises added *Aesthetics:* Not reported. *Personalisation:* Self prescribed activities	The website was in browser format and participants navigate the website freely in non-linear pathway.
A computer and embodied conversational agent based physical activity programme [17].	To promote health behaviour change of older adults with low education and health literacy levels.	Goal setting; Review of progress; Positive reinforcement; Barrier identification; Problem solving Self-monitoring.	Simulated face-to-face encounters with an embodied conversational agent (Virtual coach); Animated characters demonstrating exercises; Step count charts; Daily exercise tips.	*Medium:* Interactive conversations with agent by choosing replies from multiple options; Images; Exercise demos. *Complexity:* Not reported *Aesthetics:* Intuitive and acceptable *Personalisation:* Self-monitoring charts to track step counts.	Participants were given touch-screen tablet computers and taught how to use the conversational agent system and have daily conversations for two months. At two months, they were shown how to use a Kiosk computer (had same ECA conversations) when waiting for the scheduled clinical appointments.
An Internet based interactive physical activity programme [18, 19].	To increase daily physical activity. Based on the stages of change and I-Change Model.	Goal setting; Regular feedback; Continuous contact with digital coaches.	Accelerometer-based activity monitor; A personal-website A personal e-coach	*Medium:* Interactive website; Coaches provided updates and advice via email. *Complexity:* Not reported *Aesthetics:* Not reported. *Personalisation:* Not reported.	Participants wore the activity monitor continuously through the day and personalised physical activity targets were set.
A fully automated online balance retraining programme [20].	To facilitate central nervous system compensation mechanisms with specific vestibular rehabilitation exercises.	Goal setting; Tailored feedback; Education on dizziness, exercises and behavioural coping strategies; Cognitive restructuring; Problem solving.	Video demonstrations of exercises; Success stories; Email reminders.	*Medium:* Text and exercise videos *Complexity:* Content in lay language; large font size; bullet points *Aesthetics:* Simple look and design. *Personalisation:* Feedback and exercise prescription based on symptoms.	Participants logged in each week over 6 sessions. They undertook automatic tailored exercises based on their symptoms and balance capabilities and received symptom specific feedback each week.
iStoppFalls: An Information and Communication based system to predict and prevent falls [21].	To predict falls risk and provide tailored exercise programme for balance and feedback.	Education on falls prevention strategies and exercise safety; Feedback; Self-monitoring; Social support (integrated social media platform to interact with others).	Exergames for balance, muscle strength and Fall risk assessment; Exercise activity tracker; Monthly falls diary; Printed guidelines on exercise safety.	*Medium:* Exer-games *Complexity:* Simple to Dual-tasking for balance; Increased repetitions, sets, difficulty level for strength exercises. *Aesthetics:* Not reported. *Personalisation:* Real-time feedback	Participants were provided with a computer, a set top box, and a Microsoft Kinect sensor, a Senior Mobility Monitor to monitor mobility and performance, and Android tablet to monitor the results. Participants interacted with the virtual Avatar to do the exergames.
Move More: Web-based physical activity programme [22].	To improve self-efficacy and physical activity behaviours. Based on trans-theoretical model of health behaviour change and ecological model.	Goal setting; Education on benefits of physical activity; Overcoming barriers; Action planning; Feedback; Social support.	Success stories; Additional links; Tips for physical activity; Online forum; Local physical activity opportunities.	*Medium:* Text, Links *Complexity:* Not reported *Aesthetics:* Not reported. *Personalisation:* Physical activity journal, automatic tailored monthly feedback.	The website was in browser format and participants navigated the website in non-linear pathway.
An Internet based physical activity programme [23].	To understand the benefits of physical activity and to increase awareness of current physical activity level.	Goal setting; Education; Self-regulation; Feedback; Rewarding; Barrier identification; Ask the expert; Social support.	Graphical feedback of daily steps; Ask the expert; discussion forum; Motivational messages; Links to other physical activity sites.	*Medium:* Interactive messages *Complexity:* Not reported *Aesthetics:* Not reported. *Personalisation:* Tailored messaging	Participants logged in once a week. To begin with, education and self-awareness of physical activity were provided. Participants then set goals to increase weekly steps by 10%.

Table 3. Risk of bias assessments

Trials	Random generation	Allocation concealment	Blinding of participants	Blinding of personnel	Blinding of assessment	Incomplete outcome data	Selective bias
Bickmore 2013 [17]	Unclear	Unclear	High	High	Low	Low	Low
Geraghty 2017 [20]	Low	Low	Unclear	Low	Low	Low	Low
Gschwind 2015 [21]	Low	Unclear	High	High	Low	Low	Low
Irvine 2013 [10]	Unclear	Unclear	High	Low	Low	Low	Low
Mouton 2015 [22]	Low	Unclear	Unclear	Unclear	Low	Low	Low
Rowley 2017 [23]	Unclear	Unclear	Unclear	Unclear	High	Low	Low
Wijsman 2013 [18] & Broekhuizen 2016 [19]	Low	Unclear	High	High	High	Low	Low

Table 4. Effects of digital rehabilitation interventions on physical activity in older adults.

Trials	Variables	Digital rehabilitation/Control (N)	Assessment time points	Digital	Control	Statistical difference between groups
Bickmore 2013 [17]	Step count	132/131	Baseline 2 months (Adjusted mean) 12months (Adjusted mean)	Data not available 4041 steps 3861 steps	Data not available 3499 steps 3383 steps	Favours digital intervention.
Rowley 2017 [23]	Step count	57/51	Baseline (Mean± SD) 3 months (Mean± SD)	4688±1475 steps 10286±3022 steps	4690±1475 steps 4654±1447 steps	Favours digital intervention.
Wijsman 2013 [18] Broekhuizen 2016 [19]	Accelerometer Minutes/Day	119/116	Baseline Median (IQR) 3 month change	16.8 (18.6) Mean increase of 11.1 minutes	14.4 (23.8) Mean decrease of 0.1 minutes	Favours digital intervention.
Mouton 2015 [22]	MET Minutes/Week	52/50	Baseline (Mean± SD) 12 month change	1215.3±766.9 Change of -28.21 to 220.47	1394.9±836.34 Data not available	No significant difference.
Irvine 2013 [10]	Minutes/Week Cardiovascular activities Stretching activities Strengthening activities Balance activities	200/205	 Baseline (Mean± SD) 3 months (Mean± SD) 6 months (Mean± SD) Baseline (Mean± SD) 3 months (Mean± SD) 6 months (Mean± SD) Baseline (Mean± SD) 3 months (Mean± SD) 6 months (Mean± SD) Baseline (Mean± SD) 3 months (Mean± SD) 6 months (Mean± SD)	 53.7 ±73.5 108.6 ±72.1 122.1 ±82.9 21 ±39.6 49.1 ±48.8 50.9 ±54.5 22.5 ±52.9 53.7 ±53.7 51.5 ±59 8.4 ±20.8 35.6 ±44.1 40.4 ±57.6	 47.5 ±55.6 83.3 ±71.1 89.8 ±78.8 20.9 ±32.1 29.3 ±31.4 34.3 ±39.2 15.6 ±33.4 29.5 ±50.6 31.6 ±42 6.2 ±19.9 17.4 ±36.4 18.9 ±39.4	Favours digital intervention.

IQR: Inter-quartile range; MET: Metabolic Equivalent Task; SD: Standard Deviation.

Table 5. Effects of digital rehabilitation interventions on quality of life, vertigo, and risk of falls in older adults.

Trials	Variables	Digital rehabilitation/Control (N)	Assessment time points		Digital rehabilitation	Control	Statistical difference between groups
Gschwind 2015 [21]	EQ-5D	78/75	Baseline (Mean± SD) 3 months (Mean± SD)		0.86±0.11 0.86±0.15	0.86±0.13 0.87±0.13	No significant difference.
Irvine 2013 [10]	SF-12	200/205	SF-12 Physical Log base 10 transformation Baseline 3 months 6 months		-0.01 ±0.76 0.03 ±0.66 0.04 ±0.66	0 ±0.82 -0.07 ±0.87 -0.07 ±0.84	Favours digital intervention.
			SF-12 Mental Log base 10 transformation Baseline 3 months 6months		0.7 ±0.8 0.88 ±0.7 0.86 ±0.72	0.8 ±0.8 0.71 ±0.8 0.7 ±0.84	Favours digital intervention.
Broekhuizen 2016 [19]	RAND-36	119/116	Physical function	Baseline (Mean± SD) 3 month-change	83.40±14.98 1.84 (1.16)	84.61±15.5 0.95 (1.01)	No significant difference.
			Mental health	Baseline (Mean± SD) 3 month-change	77.24±15.52 2.52 (0.83)	77.31±15.58 -0.72 (1.19)	Favours digital intervention.
			Total RAND-36	Baseline (Mean± SD) 3 month-change	630.86±120.12 6.28 (8.13)	639.68±118.64 -0.89 (7.57)	No significant difference.
Geragty 2017 [20]	VS-SF total score	160/136	Baseline Median (IQR) 3 months Median (IQR) 6 months Median (IQR)		14 (8-22) 6 (3-12) 6 (3-14)	13 (7-22) 9 (5-15) 7 (4-17)	Favours digital intervention.
Gschwind 2015 [21]	PPA	78/75	Baseline (Mean± SD) 3 months (Mean± SD)		0.62±0.89 0.41±0.95	0.55±0.90 0.39±0.80	Favours digital intervention.

EQ-5D: European Quality of Life 5 Dimension; SF-12: 12 Item Short Form Health Survey; RAND-36: Research and Development 36 item Health Survey; VSS-SF: Vertigo Symptoms Scale–Short Form; PPA: Physiological Profile Assessment; IQR: Inter-quartile range; SD: Standard deviation.

Table 6. The quality of evidence for the effectiveness of digital rehabilitation interventions in older adults

Outcomes	Comparisons	N	Direction of treatment effect	Quality of evidence
Physical activity *Short-term*	Web-based PA intervention vs. No intervention [23] Web-based PA intervention vs. Waiting list [19] Web-based PA intervention vs. No intervention [10]	108 235 405	Favours digital intervention	⊕⊕⊕⊖ Moderate[1]
Short-term	PA intervention via animated virtual coach + Pedometer vs. Pedometer intervention [17]	263	Favours digital intervention	⊕⊖⊖⊖ Very low[2]
Medium-term	Web-based PA intervention vs. No intervention [10]	405	Favours digital intervention	⊕⊕⊕⊖ Moderate[3]
Long-term	Web-based PA intervention vs. No intervention [22]	102	No difference between groups.	⊕⊖⊖⊖ Very low [2]
Long-term	PA intervention via animated virtual coach + Pedometer vs. Pedometer intervention [17].	263	No difference between groups.	⊕⊖⊖⊖ Very low[2]
Quality of life (QoL) **QoL Physical** *Short-term*	Web-based PA intervention vs. Waiting list [19] Web-based PA intervention vs. No intervention [10]	235 405	Inconsistent results. (No difference [19]; Favours digital intervention [10])	⊕⊖⊖⊖ Very low[4]
QoL Mental *Short-term*	Web-based PA intervention vs. Waiting list [19] Web-based PA intervention vs. No intervention [10]	235 405	Favours digital intervention	⊕⊕⊖⊖ Low[5]
QoL (Total score) *Short-term*	Web-based PA intervention vs. Waiting list [19]	235	No difference between groups.	⊕⊖⊖⊖ Very low[2]
QoL (Total score) *Short-term*	Web-based Exergames vs. Falls prevention education [21]	153	No difference between groups.	⊕⊖⊖⊖ Very low[2]
QoL (Physical & Mental) *Medium-term*	Web-based PA intervention vs. No intervention [10]	405	Favours digital intervention	⊕⊕⊕⊖ Moderate[3]
Vertigo symptoms *Short & Medium-term*	Web-based balance training vs. Usual care [20]	296	Favours digital intervention	⊕⊖⊖⊖ Very low[2]
Falls *Short-term*	Web-based Exergames vs. Falls prevention education [21]	153	Favours digital intervention	⊕⊖⊖⊖ Very low[2]

[1]Downgraded to one level for risk of bias.
[2]Downgraded to three levels for risk of bias and being a single trial with <400 participants.
[3]Downgraded to one level for risk of bias.
[4]Downgraded to three levels for risk of bias, inconsistent results, and indirectness of evidence.
[5]Downgraded to two levels for risk of bias and indirectness of evidence.

Supplementary File 1

Search Strategies (06/11/18)

Database: Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to present
Search Strategy:
1 exp aged/ or middle aged/ (4673065)
2 exp Aging/ (231158)
3 elder*.ti,ab. (234110)
4 senior*.ti,ab. (35909)
5 "old* age*".ti,ab. (66736)
6 "old* person*".ti,ab. (11433)
7 "old* adult*".ti,ab. (66327)
8 "old* people*".ti,ab. (27992)
9 "ageing person*".ti,ab. (31)
10 "aging person*".ti,ab. (166)
11 "ageing adult*".ti,ab. (58)
12 "aging adult*".ti,ab. (546)
13 geriatric*.ti,ab. (42239)
14 pensioner*.ti,ab. (934)
15 frail*.ti,ab. (16859)
16 exp Veterans/ (14508)
17 veteran*.ti,ab. (31482)
18 "older population*".ti,ab. (5409)
19 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (4954039)
20 exp Internet/ (70681)
21 exp Telemedicine/ (23708)
22 exp Computers/ (74831)
23 Multimedia/ (1799)
24 exp Cell Phone/ (8998)
25 Mobile Applications/ (3491)
26 "e-health*".ti,ab. (1868)
27 ehealth*.ti,ab. (1903)
28 "m-health*".ti,ab. (306)
29 "mobile health*".ti,ab. (2239)
30 mhealth*.ti,ab. (1874)
31 compute*.ti,ab. (590929)
32 web*.ti,ab. (126521)
33 online.ti,ab. (87199)
34 internet*.ti,ab. (43887)
35 ("technology based" or technologybased or technology-based).ti,ab. (2577)
36 virtual*.ti,ab. (114260)

37	digital*.ti,ab. (121337)
38	("social media" or twitter or tweet* or facebook or blog* or microblog*).ti,ab. (10805)
39	Electronic Mail/ (2460)
40	(email* or e-mail* or "e mail*").ti,ab. (13581)
41	(telerehabilitation or tele-rehabilitation or "tele rehabilitation").ti,ab. (614)
42	(telemedicine or tele-medicine).ti,ab. (8754)
43	(mobile adj2 (phone* or telephon*)).ti,ab. (6934)
44	(cell adj2 (phone* or telephon*)).ti,ab. (2173)
45	smartphone*.ti,ab. (6782)
46	"smart phone*".ti,ab. (877)
47	"text messag*".ti,ab. (3025)
48	(txt or pxt or mms or sms).ti,ab. (9491)
49	iphone*.ti,ab. (684)
50	"voice messag*".ti,ab. (88)
51	nokia.ti,ab. (90)
52	blackberry.ti,ab. (554)
53	symbian.ti,ab. (9)
54	(windows adj3 (mobile* or phone*)).ti,ab. (49)
55	android.ti,ab. (1884)
56	ipad*.ti,ab. (1172)
57	(app* adj3 (smartphone* or smart-phone or mobile* or phone*)).ti,ab. (7751)
58	skype*.ti,ab. (289)
59	"CD rom*".ti,ab. (1258)
60	cdrom*.ti,ab. (23)
61	20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 (1117560)
62	exp Chronic Disease/ (251626)
63	exp neoplasms/ or exp musculoskeletal diseases/ or exp respiratory tract diseases/ or exp nervous system diseases/ or exp cardiovascular diseases/ or exp endocrine system diseases/ (8521078)
64	Accidental Falls/ (21350)
65	exp Fractures, Bone/ (171923)
66	chronic*.ti,ab. (1093813)
67	prolong*.ti,ab. (346981)
68	"long term*".ti,ab. (719228)
69	longterm*.ti,ab. (6226)
70	musculoskeletal*.ti,ab. (42880)
71	"musculo-skeletal*".ti,ab. (1209)
72	rheumat*.ti,ab. (167090)
73	"physical disease*".ti,ab. (906)
74	balance*.ti,ab. (249107)
75	(fall or falls or falling or fell).ti,ab. (208953)
76	stroke.ti,ab. (209265)

77	"cerebrovascular accident*".ti,ab. (6294)
78	parkinson*.ti,ab. (103281)
79	(cancer* or metasta* or tumor* or tumour* or carcinom* or malignan* or neoplasm*).ti,ab. (2962744)
80	diabet*.ti,ab. (561053)
81	neurological*.ti,ab. (201125)
82	fracture*.ti,ab. (230590)
83	(bone* adj3 (break* or broken)).ti,ab. (1112)
84	62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 (11026602)
85	exp Rehabilitation/ (279370)
86	exp Exercise/ (171234)
87	rehabilit*.ti,ab. (147504)
88	exercise*.ti,ab. (261377)
89	(physical* adj2 activ*).ti,ab. (99838)
90	activit*.ti,ab. (2808092)
91	mobilit*.ti,ab. (130746)
92	exp Physical Therapy Modalities/ (139250)
93	physio*.ti,ab. (680446)
94	"physical therap*".ti,ab. (19690)
95	balance*.ti,ab. (249107)
96	movement*.ti,ab. (283491)
97	function*.ti,ab. (3293197)
98	intervention*.ti,ab. (847363)
99	technolog*.ti,ab. (395870)
100	85 or 86 or 87 or 88 or 89 or 90 or 91 or 92 or 93 or 94 or 95 or 96 or 97 or 98 or 99 (7507059)
101	((("semi-structured" or semistructured or unstructured or informal or "in-depth" or indepth or "face-to-face" or structured or guide) adj3 (interview* or discussion* or questionnaire*)) or (focus group* or qualitative or ethnograph* or fieldwork or "field work" or "key informant")).ti,ab. or interviews as topic/ or focus groups/ or narration/ or qualitative research/ (336174)
102	randomized controlled trial.pt. (470801)
103	controlled clinical trial.pt. (92735)
104	randomized.ab. (425865)
105	placebo.ab. (193019)
106	randomly.ab. (299961)
107	trial.ab. (443885)
108	groups.ab. (1849019)
109	101 or 102 or 103 or 104 or 105 or 106 or 107 or 108 (2932974)
110	19 and 61 and 84 and 100 and 109 (17202)
111	110 (17202)
112	limit 111 to english language (16366)

Database: Embase 1974 to present
Search Strategy:
1 exp aged/ (2684689)
2 middle aged/ (1278238)
3 exp aging/ (237398)
4 elder*.ti,ab. (325725)
5 senior*.ti,ab. (49042)
6 "old* age*".ti,ab. (91916)
7 "old* person*".ti,ab. (14415)
8 "old* adult*".ti,ab. (83055)
9 "old* people".ti,ab. (33494)
10 "ageing person*".ti,ab. (51)
11 "aging person*".ti,ab. (214)
12 "ageing adult*".ti,ab. (84)
13 "aging adult*".ti,ab. (690)
14 geriatric*.ti,ab. (65525)
15 pensioner*.ti,ab. (1182)
16 frail*.ti,ab. (25205)
17 exp veteran/ (20718)
18 veteran*.ti,ab. (39688)
19 "older population*".ti,ab. (7484)
20 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 (3755970)
21 internet/ (99874)
22 exp telehealth/ (36338)
23 exp computer/ (126898)
24 multimedia/ (3488)
25 exp mobile phone/ (20727)
26 mobile application/ (6971)
27 "e-health*".ti,ab. (2481)
28 ehealth*.ti,ab. (2081)
29 "m-health*".ti,ab. (424)
30 "mobile health".ti,ab. (2240)
31 mhealth*.ti,ab. (1808)
32 compute*.ti,ab. (716158)
33 web*.ti,ab. (160335)
34 online.ti,ab. (123750)
35 internet*.ti,ab. (59032)
36 ("technology based" or technologybased or technology-based).ti,ab. (3254)
37 virtual*.ti,ab. (138170)

38	digital*.ti,ab. (148749)
39	("social media" or twitter or tweet* or facebook or blog* or microblog*).ti,ab. (14781)
40	e-mail/ (17605)
41	(email* or e-mail* or "e mail*").ti,ab. (27146)
42	(telerehabilitation or tele-rehabilitation or "tele rehabilitation").ti,ab. (759)
43	(telemedicine or tele-medicine).ti,ab. (11686)
44	text messaging/ (3673)
45	(mobile adj2 (phone* or telephon*)).ti,ab. (8592)
46	(cell adj2 (phone* or telephon*)).ti,ab. (2962)
47	smartphone*.ti,ab. (8992)
48	"smart phone*".ti,ab. (1774)
49	"text messag*".ti,ab. (3949)
50	(txt or pxt or mms or sms).ti,ab. (12787)
51	iphone*.ti,ab. (1360)
52	"voice messag*".ti,ab. (125)
53	nokia.ti,ab. (119)
54	blackberry.ti,ab. (700)
55	symbian.ti,ab. (15)
56	(windows adj3 (mobile* or phone*)).ti,ab. (71)
57	android.ti,ab. (3012)
58	ipad*.ti,ab. (2449)
59	(app* adj3 (smartphone* or smart-phone or mobile* or phone*)).ti,ab. (10276)
60	skype*.ti,ab. (611)
61	"CD rom*".ti,ab. (1453)
62	cdrom*.ti,ab. (42)
63	21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 (1408669)
64	exp physical disease/ (17816871)
65	exp chronic disease/ (163610)
66	falling/ (36383)
67	exp fracture/ (255309)
68	chronic*.ti,ab. (1484638)
69	prolong*.ti,ab. (454207)
70	"long term*".ti,ab. (973815)
71	longterm*.ti,ab. (23551)
72	musculoskeletal*.ti,ab. (58735)
73	"musculo-skeletal*".ti,ab. (1755)
74	rheumat*.ti,ab. (238304)
75	"physical disease*".ti,ab. (1250)
76	balance*.ti,ab. (314131)
77	(fall or falls or falling or fell).ti,ab. (266941)
78	stroke.ti,ab. (329781)
79	"cerebrovascular accident*".ti,ab. (9339)

80 parkinson*.ti,ab. (144706)
81 (cancer* or metasta* or tumor* or tumour* or carcinom* or malignan* or neoplasm*).ti,ab. (3829935)
82 diabet*.ti,ab. (819499)
83 neurological*.ti,ab. (294533)
84 fracture*.ti,ab. (267395)
85 (bone* adj3 (break* or broken)).ti,ab. (1490)
86 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 (19033110)
87 exp rehabilitation/ (347360)
88 exp exercise/ (298442)
89 exp physical activity/ (359659)
90 rehabilit*.ti,ab. (204091)
91 exercise*.ti,ab. (342719)
92 (physical* adj2 activ*).ti,ab. (134778)
93 activit*.ti,ab. (3392656)
94 joint mobility/ (16459)
95 mobilit*.ti,ab. (148236)
96 exp physiotherapy practice/ or exp physiotherapy/ or exp home physiotherapy/ (76521)
97 physio*.ti,ab. (847766)
98 "physical therap*".ti,ab. (28349)
99 balance*.ti,ab. (314131)
100 movement*.ti,ab. (346621)
101 function*.ti,ab. (4016723)
102 intervention*.ti,ab. (1165427)
103 technolog*.ti,ab. (522827)
104 87 or 88 or 89 or 90 or 91 or 92 or 93 or 94 or 95 or 96 or 97 or 98 or 99 or 100 or 101 or 102 or 103 (9298629)
105 (("semi-structured" or semistructured or unstructured or informal or "in-depth" or indepth or "face-to-face" or structured or guide) adj3 (interview* or discussion* or questionnaire*)).ti,ab. (134179)
106 (focus group* or qualitative or ethnograph* or fieldwork or "field work" or "key informant").ti,ab. (271972)
107 interviews as topic/ (126382)
108 focus groups/ (176773)
109 narration/ (13297)
110 qualitative research/ (57859)
111 random$.tw. (1347860)
112 factorial$.tw. (33668)
113 crossover$.tw. (67891)
114 cross over$.tw. (29790)
115 placebo$.tw. (280363)
116 (doubl$ adj blind$).tw. (192329)
117 (singl$ adj blind$).tw. (21872)

118	assign$.tw. (349128)
119	allocat$.tw. (132321)
120	volunteer$.tw. (237135)
121	Crossover Procedure/ (57187)
122	"double-blind procedure".tw. (1)
123	Randomized Controlled Trial/ (521873)
124	Single Blind Procedure/ (32981)
125	105 or 106 or 107 or 108 or 109 or 110 or 111 or 112 or 113 or 114 or 115 or 116 or 117 or 118 or 119 or 120 or 121 or 122 or 123 or 124 (2613231)
126	trial.ti,ab. (736974)
127	125 or 126 (2902666)
128	20 and 63 and 86 and 104 and 127 (15823)
129	128 (15823)
130	limit 129 to english language (15361)

Ebsco CINAHL

	Query	Limiters/Expanders	Last Run Via	Results n
S123	S19 AND S62 AND S90 AND S108 AND S121	Narrow by Language: - english Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	3,623
S122	S19 AND S62 AND S90 AND S108 AND S121	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	3,661
S121	S109 OR S110 OR S111 OR S112 OR S113 OR S114 OR S115 OR S116 OR S117 OR S118 OR S119 OR S120	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced	483,412

			Search Database - CINAHL	
S120	TI ((singl* blind*) or (doubl* blind*) or (tripl* blind*) or (trebl* blind*) or (trebl* mask*) or (tripl* mask*) or (doubl* mask*) or (singl* mask*)) OR AB ((singl* blind*) or (doubl* blind*) or (tripl* blind*) or (trebl* blind*) or (trebl* mask*) or (tripl* mask*) or (doubl* mask*) or (singl* mask*))	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	37,849
S119	TI Randomi?ed control* trial* OR AB Randomi?ed control* trial*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	92,652
S118	TI placebo* OR AB placebo*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	48,148
S117	(MH "Random Assignment")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	51,988
S116	(MH "Placebos")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen -	10,962

			Advanced Search Database - CINAHL	
S115	(MH "Quantitative Studies")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	21,254
S114	TI allocat* random* OR AB allocat* random*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	9,469
S113	TI (focus group* or qualitative or ethnograph* or fieldwork or "field work" or "key informant") OR AB (focus group* or qualitative or ethnograph* or fieldwork or "field work" or "key informant")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	117,680
S112	TI (("semi-structured" or semistructured or unstructured or informal or "in-depth" or indepth or "face-to-face" or structured or guide) n3 (interview* or discussion* or questionnaire*)) OR AB (("semi-structured" or semistructured or unstructured or informal or "in-depth" or indepth or "face-to-face" or structured or guide) n3 (interview* or discussion* or questionnaire*))	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	63,091
S111	(MH "Ethnographic Research")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search	6,974

			Screen - Advanced Search Database - CINAHL	
S110	(MH "Qualitative Studies+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	121,879
S109	(MH "Interviews+") OR (MH "Focus Groups") OR (MH "Narratives")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	218,258
S108	S91 OR S92 OR S93 OR S94 OR S95 OR S96 OR S97 OR S98 OR S99 OR S100 OR S101 OR S102 OR S103 OR S104 OR S105 OR S106 OR S107	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,238,077
S107	TI technolog* OR AB technolog*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	95,007
S106	TI intervention* OR AB intervention*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases	333,657

			Search Screen - Advanced Search Database - CINAHL	
S105	TI function* OR AB function*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	342,044
S104	TI movement* OR AB movement*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	48,337
S103	TI balance* OR AB balance*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	47,136
S102	TI "physical therap*" OR AB "physical therap*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	16,808
S101	TI physio* OR AB physio*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research	74,627

			Databases Search Screen - Advanced Search Database - CINAHL	
S100	(MH "Physical Therapy+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	119,639
S99	TI mobilit* OR AB mobilit*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	21,198
S98	TI activit* OR AB activit*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	260,293
S97	TI physical* n2 activ* OR AB physical* n2 activ*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	49,526
S96	TI exercise* OR AB exercise*	Search modes - Boolean/Phrase	Interface - EBSCOhost	93,509

			Research Databases Search Screen - Advanced Search Database - CINAHL	
S95	TI rehabilit* OR AB rehabilit*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	74,956
S94	(MH "Joint Mobilization")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	768
S93	(MH "Physical Activity")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	32,177
S92	(MH "Exercise+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	93,339

S91	(MH "Rehabilitation+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	241,272
S90	S63 OR S64 OR S65 OR S66 OR S67 OR S68 OR S69 OR S70 OR S71 OR S72 OR S73 OR S74 OR S75 OR S76 OR S77 OR S78 OR S79 OR S80 OR S81 OR S82 OR S83 OR S84 OR S85 OR S86 OR S87 OR S88 OR S89	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	2,177,370
S89	TI (bone* n3 (break* or broken)) OR AB (bone* n3 (break* or broken))	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	288
S88	TI fracture* OR AB fracture*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	55,781
S87	TI neurological* OR AB neurological*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search	31,620

			Database - CINAHL	
S86	TI diabet* OR AB diabet*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	154,177
S85	TI (cancer* or metasta* or tumor* or tumour* or carcinom* or malignan* or neoplasm*) OR AB (cancer* or metasta* or tumor* or tumour* or carcinom* or malignan* or neoplasm*)	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	438,844
S84	TI parkinson* OR AB parkinson*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	21,020
S83	TI "cerebrovascular accident*" OR AB "cerebrovascular accident*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,353
S82	TI stroke OR AB stroke	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced	72,953

			Search Database - CINAHL	
S81	TI (fall or falls or falling or fell) OR AB (fall or falls or falling or fell)	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	43,394
S80	TI balance* OR AB balance*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	47,136
S79	TI "physical disease*" OR AB "physical disease*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	261
S78	TI rheumat* OR AB rheumat*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	28,167
S77	TI "musculo-skeletal*" OR AB "musculo-skeletal*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen -	252

			Advanced Search Database - CINAHL	
S76	TI musculoskeletal* OR AB musculoskeletal*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	19,406
S75	TI longterm* OR AB longterm*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,142
S74	TI "long term*" OR AB "long term*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	137,633
S73	TI prolong* OR AB prolong*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	40,418
S72	TI chronic* OR AB chronic*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search	199,208

			Screen - Advanced Search Database - CINAHL	
S71	(MH "Fractures+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	47,499
S70	(MH "Accidental Falls")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	18,599
S69	(MH "Endocrine Diseases+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	263,090
S68	(MH "Cardiovascular Diseases+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	473,431
S67	(MH "Nervous System Diseases+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases	615,504

			Search Screen - Advanced Search Database - CINAHL	
S66	(MH "Respiratory Tract Diseases+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	235,349
S65	(MH "Musculoskeletal Diseases+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	218,708
S64	(MH "Neoplasms+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	441,955
S63	(MH "Chronic Disease")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	53,110
S62	S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36	Search modes - Boolean/Phrase	Interface - EBSCOhost Research	362,628

	OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61		Databases Search Screen - Advanced Search Database - CINAHL	
S61	TI cdrom* OR AB cdrom*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	39
S60	TI "CD rom*" OR AB "CD rom*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,085
S59	TI skype* OR AB skype*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	237
S58	TI (app* n3 (smartphone* or smart-phone or mobile* or phone*)) OR AB (app* n3 (smartphone* or smart-phone or mobile* or phone*))	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	4,413
S57	TI ipad* OR AB ipad*	Search modes - Boolean/Phrase	Interface - EBSCOhost	832

			Research Databases Search Screen - Advanced Search Database - CINAHL	
S56	TI android* OR AB android*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	595
S55	TI (windows n3 (mobile* or phone*)) OR AB (windows n3 (mobile* or phone*))	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	28
S54	TI symbian OR AB symbian	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	3
S53	TI blackberry OR AB blackberry	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	132

S52	TI nokia OR AB nokia	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	40
S51	TI "voice messag*" OR AB "voice messag*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	48
S50	TI iphone* OR AB iphone*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	512
S49	TI (txt or pxt or mms or sms) OR AB (txt or pxt or mms or sms)	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,447
S48	TI "text messag*" OR AB "text messag*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search	1,942

			Database - CINAHL	
S47	TI "smart phone*" OR AB "smart phone*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	395
S46	TI smartphone* OR AB smartphone*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	3,500
S45	TI (cell n2 (phone* or telephon*)) OR AB (cell n2 (phone* or telephon*))	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,192
S44	TI (mobile n2 (phone* or telephon*)) OR AB (mobile n2 (phone* or telephon*))	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	2,636
S43	TI (telemedicine or tele-medicine) OR AB (telemedicine or tele-medicine)	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced	3,911

			Search Database - CINAHL	
S42	TI (telerehabilitation or tele-rehabilitation or "tele rehabilitation") OR AB (telerehabilitation or tele-rehabilitation or "tele rehabilitation")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	367
S41	TI (email* or e-mail* or "e mail*") OR AB (email* or e-mail* or "e mail*")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	7,915
S40	(MH "Electronic Mail")	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	991
S39	(MH "Electronic Mail")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	0
S38	TI ("social media" or twitter or tweet* or facebook or blog* or microblog*) OR AB ("social media" or twitter or tweet* or facebook or blog* or microblog*)	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen -	12,266

			Advanced Search Database - CINAHL	
S37	TI digital* OR AB digital*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	26,504
S36	TI virtual* OR AB virtual*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	17,174
S35	TI ("technology based" or technologybased or technology-based) OR AB ("technology based" or technologybased or technology-based)	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	880
S34	TI internet* OR AB internet*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	24,751
S33	TI online OR AB online	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search	47,302

			Screen - Advanced Search Database - CINAHL	
S32	TI web* OR AB web*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	53,766
S31	TI compute* OR AB compute*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	109,582
S30	TI mhealth* OR AB mhealth*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	999
S29	TI "mobile health*" OR AB "mobile health*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,108
S28	TI "m-health*" OR AB "m-health*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases	139

			Search Screen - Advanced Search Database - CINAHL	
S27	TI ehealth* OR AB ehealth*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,564
S26	TI "e-health*" OR AB "e-health*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,152
S25	(MH "Mobile Applications")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	4,410
S24	(MH "Mobile Applications")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	4,410
S23	(MH "Cellular Phone+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research	4,733

			Databases Search Screen - Advanced Search Database - CINAHL	
S22	(MH "Multimedia")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,852
S21	(MH "Telehealth+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	17,746
S20	(MH "Internet+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	121,755
S19	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,141,739
S18	TI "older population*" OR AB "older population*"	Search modes - Boolean/Phrase	Interface - EBSCOhost	2,454

			Research Databases Search Screen - Advanced Search Database - CINAHL	
S17	TI veteran* OR AB veteran*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	17,068
S16	TI frail* OR AB frail*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	9,144
S15	TI pensioner* OR AB pensioner*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	190
S14	TI geriatric* OR AB geriatric*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	18,974

S13	TI "aging adult*" OR AB "aging adult*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	317
S12	TI "ageing adult*" OR AB "ageing adult*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	26
S11	TI "aging person*" OR AB "aging person*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	60
S10	TI "ageing person*" OR AB "ageing person*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	19
S9	TI "old* people" OR AB "old* people"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search	19,580

			Database - CINAHL	
S8	TI "old* adult*" OR AB "old* adult*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	44,437
S7	TI "old* person*" OR AB "old* person*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	6,413
S6	TI "old* age*" OR AB "old* age*"	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	17,983
S5	TI senior* OR AB senior*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	19,649
S4	TI elder* OR AB elder*	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced	82,198

			Search Database - CINAHL	
S3	(MH "Veterans+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	13,422
S2	(MH "Aging+")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	43,966
S1	(MH "Aged+") OR (MH "Middle Age")	Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL	1,058,000

Cochrane Central Register of Controlled Trials		
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ID	Search Hits	n
#1	MeSH descriptor: [Aged] explode all trees	1696
#2	MeSH descriptor: [Middle Aged] explode all trees	1406
#3	MeSH descriptor: [Aging] explode all trees	3503
#4	elder*.ti,ab.	0
#5	senior*.ti,ab.	0
#6	"old* age*".ti,ab.	5122
#7	"old* person*".ti,ab.	4267

#8	"old* adult*".ti,ab.	4277
#9	"old* people".ti,ab.	4489
#10	"ageing person*".ti,ab.	4258
#11	"aging person*".ti,ab.	4258
#12	"ageing adult*".ti,ab.	4269
#13	"aging adult*".ti,ab.	4269
#14	geriatric*.ti,ab.	0
#15	pensioner*.ti,ab.	0
#16	frail*.ti,ab.	0
#17	MeSH descriptor: [Veterans] explode all trees	802
#18	veteran*.ti,ab.	0
#19	"older population*".ti,ab.	4628
#20	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19	11701
#21	MeSH descriptor: [Internet] explode all trees	3372
#22	MeSH descriptor: [Telemedicine] explode all trees	1950
#23	MeSH descriptor: [Computers] explode all trees 1425	
#24	MeSH descriptor: [Multimedia] explode all trees 200	
#25	MeSH descriptor: [Cell Phone] explode all trees 1030	
#26	MeSH descriptor: [Mobile Applications] explode all trees	324
#27	"e-health*".ti,ab.	7049
#28	ehealth*.ti,ab.	0
#29	"m-health*".ti,ab.	6773
#30	"mobile health*".ti,ab.	4827
#31	mhealth*.ti,ab.	0
#32	compute*.ti,ab.	0
#33	web*.ti,ab.	0
#34	online.ti,ab.	2
#35	internet.ti,ab.	7
#36	("technology based" or technologybased or technology-based).ti,ab.	4258
#37	virtual*.ti,ab.	0
#38	digital*.ti,ab.	0
#39	("social media" or twitter or tweet* or facebook or blog* or microblog*).ti,ab.	4260
#40	MeSH descriptor: [Electronic Mail] explode all trees	293
#41	(email* or e-mail* or "e mail*").ti,ab.	4294
#42	(telerehabilitation or tele-rehabilitation or "tele rehabilitation").ti,ab.	4258
#43	(telemedicine or tele-medicine).ti,ab.	4259
#44	(mobile near/2 (phone* or telephon*)).ti,ab.	4258
#45	(cell near/2 (phone* or telephon*)).ti,ab.	4258
#46	smartphone*.ti,ab.	0
#47	"smart phone*".ti,ab.	4496
#48	"text messag*".ti,ab.	4274
#49	(txt or pxt or mms or sms).ti,ab.	4258

#50	iphone*.ti,ab.	0
#51	"voice messag*".ti,ab.	4260
#52	nokia.ti,ab.	7
#53	blackberry.ti,ab.	1
#54	symbian.ti,ab.	0
#55	(windows near/2 (mobile* or phone*)).ti,ab.	4258
#56	android.ti,ab.	8
#57	ipad*.ti,ab.	0
#58	(app* near/3 (smartphone* OR smart-phone* OR mobile* OR phone*)).ti,ab.	4258
#59	skype*.ti,ab.	0
#60	"cd rom*".ti,ab.	4491
#61	cdrom*.ti,ab.	0
#62	#21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61	15663
#63	MeSH descriptor: [Chronic Disease] explode all trees	12335
#64	MeSH descriptor: [Neoplasms] explode all trees 67613	
#65	MeSH descriptor: [Musculoskeletal Diseases] explode all trees	34576
#66	MeSH descriptor: [Respiratory Tract Diseases] explode all trees	52607
#67	MeSH descriptor: [Nervous System Diseases] explode all trees	72091
#68	MeSH descriptor: [Cardiovascular Diseases] explode all trees	94071
#69	MeSH descriptor: [Endocrine System Diseases] explode all trees	35730
#70	MeSH descriptor: [Accidental Falls] explode all trees	1283
#71	MeSH descriptor: [Fractures, Bone] explode all trees	5196
#72	chronic*.ti,ab.	0
#73	prolong*.ti,ab.	0
#74	"long term*".ti,ab.	80028
#75	longterm*.ti,ab.	0
#76	musculoskeletal*.ti,ab.	0
#77	musculo-skeletal*.ti,ab.	0
#78	rheumat*.ti,ab.	0
#79	"physical disease*".ti,ab.	4865
#80	balance*.ti,ab.	0
#81	(fall or falls or falling or fell).ti,ab.	4275
#82	stroke.ti,ab.	11
#83	"cerebrovascular accident*".ti,ab.	12172
#84	parkinson*.ti,ab.	0
#85	(cancer* or metasta* or tumor* or tumour* or carcinom* or malignan* or neoplasm*).ti,ab.	4276
#86	diabet*.ti,ab.	0
#87	neurological*.ti,ab.	0
#88	fracture*.ti,ab.	0
#89	(bone* near/3 (break* or broken)).ti,ab.	4258

#90	#63 or #64 or #65 or #66 or #67 or #68 or #69 or #70 or #71 or #72 or #73 or #74 or #75 or #76 or #77 or #78 or #79 or #80 or #81 or #82 or #83 or #84 or #85 or #86 or #87 or #88 or #89	367193
#91	MeSH descriptor: [Rehabilitation] explode all trees	30780
#92	MeSH descriptor: [Exercise] explode all trees	20923
#93	rehabilit*.ti,ab.	0
#94	exercise*.ti,ab.	0
#95	(physical* near/2 activ*).ti,ab.	4258
#96	activit*.ti,ab.	0
#97	mobilit*.ti,ab.	0
#98	MeSH descriptor: [Physical Therapy Specialty] explode all trees	117
#99	physio*.ti,ab.	0
#100	"physical therap*".ti,ab.	4294
#101	balance*.ti,ab.	0
#102	movement*.ti,ab.	0
#103	function*.ti,ab.	0
#104	intervention*.ti,ab.	0
#105	technolog*.ti,ab.	0
#106	#91 or #92 or #93 or #94 or #95 or #96 or #97 or #98 or #99 or #100 or #101 or #102 or #103 or #104 or #105	49447
#107	#20 and #62 and #90 and #106	4318

Search Strategies (08/11/18)

PEDro https://search.pedro.org.au/advanced-search/continue-search

The Abstract & Title field was searched for combinations for each of the following terms from two sets of concepts:

Elder*; senior*; older; aging; ageing; geriatric*; pensioner*; frail*; veteran*;

AND

Internet*; telehealth*; compute*; multimedia*; phone; e-health*; ehealth*; “mobile health”; m-health*; mhealth*; web*; online*; technolog*; virtual*; digital*; “social media”; twitter; tweet; facebook; blog*; microblog*; email*; e-mail*; “e mail*”; telerehab*; “tele-rehab*”; “tele rehab*”; telemedicine; tele-medicine; “text messag*”; “cell telephon*”; smartphone*; “smart-phone*”; txt; pxt; mms; sms; iphone*; “voice messag*”; nokia; blackberry; Symbian; windows; android; ipad*; skype*; “cd rom*”; cdrom*.

For example: elder* AND internet*

Manually removing non-English-language references

Search Results

Ovid Medline (searched 06/11/18)	16366
Ovid Embase (searched 06/11/18)	15361
Ebsco CINAHL (searched 06/11/18)	3623
Cochrane CENTRAL (searched 06/11/18)	27
PEDro (searched 07/11/18)	454
Total	35831
Total after deduplication	25961