# Effects of remote feedback in home-based physical activity interventions for older adults

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Review

# Effects of remote feedback in home-based physical activity interventions for older adults: A systematic review

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ABSTRACT

*Objective:* To evaluate the literature on effectiveness of remote feedback on physical activity and capacity in home-based physical activity interventions for older adults with or without medical conditions. In addition, the effect of remote feedback on adherence was inventoried.
*Methods:* A systematic review. Data sources included PubMed, PsycInfo, Cochrane and EMBASE. A best-evidence synthesis was used for qualitative summarizing of results.
*Results:* Twenty-four studies met the inclusion criteria for systematic effectiveness evaluation and 22 for adherence inventory. Three categories of contact were identified: frequent, non-frequent, and direct remote contact during exercising. Evidence for positive enhancement of physical activity or capacity varied from conflicting in frequent contact strategies (16 studies) to strong in non-frequent (5 studies) and direct contact strategies (3 studies). Adherence rates in intervention groups were similar or higher than treatment-as-usual or exercise control groups.
*Conclusion:* Results imply with varying strength that interventions using frequent, non-frequent or direct remote feedback seem more effective than treatment as usual and equally effective as supervised exercise interventions. Direct remote contact seems a particularly good alternative to supervised onsite exercising.
*Practice implications:* Remote feedback is promising in an older population getting increasingly used to new technology.



## 1. Introduction

The number of older persons in our society is growing: in the Netherlands, the group of people aged 65 or older comprised 14% of the population in 2010, and by 2040 this percentage will be 23% [1]. In the United States these numbers will reach 72.1 million individuals by 2030, roughly an estimated 20% of the US population [2]. In general, older persons are in need of more chronic monitoring of health and health care than younger individuals. As a result, the burden on the health care system will grow.

There is ample evidence that a physically active lifestyle can improve and maintain general health and quality of life in older adults, leading to a lower use of health care resources and longer independent living [3]. It is therefore important to keep people physically active as they age. Current physical activity recommendations advise older adults to perform moderate-intensity aerobic physical activity for a minimum of 30 min five days a week or vigorous-intensity aerobic activity for a minimum of 20 min three days a week [4]. Based on these recommendations, 61% of U.S. older adults (2005) and 41.6% of Dutch older adults (2009) can be considered physically inactive [5,6]. Older adults face multiple barriers to exercising regularly and therefore experience difficulties starting with a physical activity program and adhering to it. These barriers include lack of transportation to an exercise facility, fear of falling, and lack of knowledge about the beneficial effects of physical activity [3].

Home-based physical activity interventions for older adults with or without comorbidities show promising results in enhancing starting and adherence to physical activity interventions [7]. Providing physical activity interventions in the home situation has several advantages, considering the barriers to exercise that older adults face. It removes the barrier of transportation, and makes it easier to integrate physical activity into daily life.

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However, home-based physical activity interventions also pose challenges. For instance, according to Social Cognitive Theory (SCT) an important factor in adherence is feedback and encouragement [8], yet these are difficult to provide when people exercise on their own [9] and no live supervision is available. Providing remote feedback or counseling in home-based physical activity interventions might be able to replace live supervision. Remote feedback or counseling is defined here as any structural contact between a coach or instructor with a participant that does not concern a physical meeting, and is aimed at enhancing effectiveness or adherence of a physical activity program. A commonly used tool for remote feedback is the telephone, but recently internet and video use have been expanding and might provide more possibilities than telephone contact. Messaging devices and internet-based strategies have also been reported [10,11]. New technological advances for providing remote feedback in home-based physical activity interventions for older adults might positively influence effectiveness in enhancing target health-related outcome measures or stimulating physical activity.

It should be noted however that the effectiveness of remote feedback in home-based interventions is unknown. The main objective of this systematic review is therefore to evaluate the existing literature on the effectiveness of remote feedback strategies on physical activity and capacity in home-based physical activity interventions for older adults with or without comorbidities. In addition, a non-systematic inventory of the effect of remote feedback strategies on adherence to home-based physical activity interventions was conducted.

## 2. Methods

### 2.1. Search strategies

Potentially relevant articles were retrieved from the databases PubMed, PsycInfo, Cochrane Controlled Trials Register and EMBASE. The literature search was limited to articles published between 1990 and July 2012. The principal search strategy was designed in PubMed using MeSH key terms and free terms. The search strategies used in PsycInfo, Cochrane Controlled Trials Register and EMBASE were tailored versions of this search strategy. Search terms used in PubMed were:

**Key term #1:** homebased OR home OR home-based
**Key term #2:** remote OR stimulation OR coaching OR feedback
**Key term #3:** monitoring OR telemonitoring OR telecommunication OR tele-communication OR telephone (NOT "telephone survey" OR "telephone surveys") OR physiotherapy OR "Physical therapy" OR telerehabilitation OR tele-rehabilitation OR rehabilitation OR tele-exercise OR telecare OR tele-care OR tele-training OR teletraining OR telemedicine OR tele-medicine
**Key term #4**: fitness OR balance OR mobility OR exercise OR "physical activity" OR activity OR "**Physical Fitness**" OR **Exercise** OR "**Motor Activity**" OR "**Psychomotor Performance**" OR "**Exercise Movement Techniques**" OR "**Postural balance**"
**Key term #5:** ("**Middle age**" OR **Aged**) OR ("older subjects" OR "old subjects" OR "old persons" OR "middle aged" OR elderly OR elders OR "older adults" OR "older people" OR seniors OR middle-aged)

The bold terms are Medical Subjects Headings (MeSH) key terms. Search lines are connected as follows: #1 AND (#2 OR #3) AND #4 AND #5. To identify further studies, a related-articles search was conducted in PubMed and the reference lists of included articles for this review were scanned.

### 2.2. Selection of studies

After performing the searches in the databases, all duplicates were removed. The remaining references were scanned on title and abstract by two reviewers (HG & AZ) independently. Subsequently, the remaining articles were checked for relevancy for either the research question on effectiveness or the research question on adherence through full-text reading by the two reviewers independently. Discrepancies between the two reviewers were solved by discussion and a third reviewer (WZ) was consulted if disagreement persisted.

The following general inclusion criteria were formulated for study selection:

(1) The study assesses a physical activity intervention program in the home situation. In this review home-based physical activity interventions are defined as structured physical activity interventions exclusively situated in the participants' home, aimed at raising their (daily) physical activity or physical capacity.
(2) The study includes at least one study group that receives the intervention exclusively in the home situation.
(3) The study mentions remote feedback used in the physical activity program, which does not include any structural contact that is not remote except for effect measurements and explanation of or initiation into the exercise program.
(4) The study addresses at least one aspect of general physical activity behavior or physical capacity as a primary or secondary outcome measure. Studies that only report disease-specific physical outcome measures were excluded.
(5) The study concerns at least one group of participants aged 55 years and older on average.
(6) The study is neither a case study nor a review.
(7) The article is in the English, Dutch or German language.

Two additional inclusion criteria were defined for the effectiveness research question: (1) the design is a controlled trial with an exercise or non-exercise control group, (2) the study receives a Physiotherapy Evidence Database (PEDro) score of at least 4 out of 10 in PEDro items 2–11 as shown in Table 1 [12]. To be included in the adherence analysis, studies needed to address adherence in addition to the general selection criteria. Adherence in this review was defined as "the degree to which a person correctly follows a prescribed exercise routine".

### 2.3. Quality assessment

The PEDro scale was used to evaluate the quality of the studies. The full list is shown in Table 1. Answer categories of PEDro items are "yes" or "no" (1 or 0 points per item) and quality assessment includes items 2–11 addressing internal and statistical validity. The reliability of the PEDro score is considered fair to good [12]. Quality assessment was performed independently by two researchers (HG & AZ), and any disagreements were solved by a third researcher (WZ). Based on guidelines for systematic reviews a study was considered to be of high quality when the sum score on the PEDro items 2–11 was 6 out of 10 or higher [13–15]. Quality assessment results of the studies were used to classify level of evidence. The best-evidence synthesis method identifies five levels of evidence [13]:

- Strong evidence: generally consistent findings in multiple high-quality studies ($\geq$75% of the studies report consistent findings).
- Moderate evidence: generally consistent findings in one high-quality study and one or more low-quality studies, or generally

**Table 1**
Quality rating of the selected studies.

| Criteria of the PEDro scale |
|---|
| *External validity* |
| 1. Eligibility criteria were specified.[a] |
| *Internal and statistical validity* |
| 2. Subjects were randomly allocated to groups. |
| 3. Allocation was concealed. |
| 4. The groups were similar at baseline on the most important prognostic indicators. |
| 5. There was blinding of all subjects. |
| 6. There was blinding of all therapists who administered the therapy. |
| 7. There was blinding of all assessors who measured at least one key outcome. |
| 8. Measurements of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups. |
| 9. All subjects for whom outcome measures were available received the treatment or control condition as allocated; where this was not the case, data for at least one key outcome were analyzed by "intention to treat". |
| 10. The results of between-group statistical comparisons are reported for at least one key outcome. |
| 11. The study provides both point measurements and measurements of variability for at least one key outcome. |

[a] Quality rating only includes items 2–11.

consistent findings in multiple low-quality studies (≥75% of the studies report consistent findings).
- Limited evidence: only one study (high- or low-quality).
- Conflicting evidence: inconsistent findings in multiple studies (<75% of studies report consistent findings).
- no evidence: no randomized controlled trials (RCTs) or non-RCTs.

### 2.4. Quantitative analysis

Effectiveness analysis of extracted data from the included articles was conducted in line with guidelines for systematic reviews from the Cochrane Collaboration Back Review Group whenever data was available [14]. The standard mean difference (SMD) with corresponding 95% confidence interval was calculated for each available outcome. Values were interpreted as follows: 0.2–0.4 is a small effect, 0.5–0.7 moderate and ≥0.8 large [16]. Analysis was conducted using Review Manager 5 (version 5.1.6, The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). When raw means or their standard deviations were missing, authors were contacted to retrieve these data in order to calculate standard mean differences. However, these efforts were unsuccessful. We therefore chose to only mention available SMDs. Data summarizing will be performed by a qualitative best-evidence synthesis [13,14].

## 3. Results

The full selection procedure flow chart is shown in Fig. 1. The search strategy identified 2521 unique articles. After scanning their titles, 641 articles were included. Abstract reading resulted in 114 articles; after full-text reading of these, 32 articles were left for total inclusion. Agreement between reviewers for the abstract screening was 84.8%. Three articles were excluded due to a PEDro score below 4 [17–19]. Twenty-four articles were finally included in the effectiveness evaluation. The agreement between raters on the 24 included studies was 96%. The range of PEDro scores was between 4 and 7, with a median score of 6. Twenty-two articles were finally included in the adherence evaluation, exclusion being in most cases a lack of reporting on adherence.

The characteristics of the studies included are shown in detail in Table 2. Remote contact frequencies of included studies varied, therefore these studies were divided into three groups according to frequency of contact: (1) studies using frequent telephone contact (>once a month during most of the intervention), (2) studies using non-frequent telephone contact (≤once a month during most of the intervention), and (3) studies using direct remote contact during exercising.

### 3.1. Effectiveness of remote feedback strategies

Fourteen high-quality studies and 10 low-quality studies were included in the systematic effectiveness evaluation [7,20–42]. See Table 2 for quality scores.

#### 3.1.1. Frequent telephone contact

The frequent-contact group included eight studies rated high-quality (PEDro ≥ 6) [20–27] and eight low-quality [7,28–34]. Evidence in the 16 studies was conflicting though, as fewer than 75% reported consistent findings. In a majority the intervention group was compared with a control group that received no intervention, received care as usual, was placed on a waiting list, etc. The intervention groups in these twelve studies showed comparable or significantly better results on physical capacity measures. For two of these studies it was possible to calculate SMDs [25,34]. Effect sizes were −0.82 (−1.10 to 0.54) and 2.06 (0.98–3.13), illustrating the variability in effectiveness. Four out of 16 studies compared programs with feedback to an exercising control group without feedback [7,22,26,32]. Results show that physical activity programs with frequent remote feedback are equally effective in enhancing physical capacity measures as (supervised) exercise programs without remote feedback. For one study SMDs on four variables could be calculated, respectively −0.21 (−0.47 to 0.04), −0.05 (−0.03 to 0.21), 0.17 (−0.08 to 0.43) and 0.2 (−0.05 to 0.45) [22]. Overall effect size was 0.03 (−0.1 to 0.15).

#### 3.1.2. Non-frequent telephone contact

The non-frequent telephone contact group included five studies [35–39], two high-quality [35,36] and three low-quality [37–39]. The studies reported generally consistent findings, thus providing strong evidence. In three studies the intervention group was compared with a control group that received care as usual, etc. Results show that programs using non-frequent contact were more effective in enhancing physical activity and capacity measures than usual-care or non-exercise control groups [35–37]. Two out of five studies compared programs with feedback to an exercising control group without feedback or exercise guidelines [38,39]. The results show that programs using non-frequent remote feedback have similar effects on physical capacity measures to supervised exercise. For one study SMDs on three variables could be calculated [38]. Effect sizes were −0.18 (−0.31 to 0.05), −0.23 (−0.36 to 0.10) and −0.06 (−0.19 to 0.07). General effect size was −0.16 (−0.23 to 0.08).

#### 3.1.3. Direct remote contact

The direct-remote-contact-during-exercising group consisted of three studies using live feedback during exercising by Internet, video or telephone: two high-quality studies [40,41] and one low-quality study [42] that report generally consistent findings and therefore provide strong evidence. In one study the control group received usual care [40]. Results show that physical activity declined significantly less in the intervention group compared to the control group. Two out of three studies compared programs with direct feedback to an exercising control group without feedback [41,42]. Results show that programs using direct remote feedback during exercising have similar effects on physical capacity measures to supervised

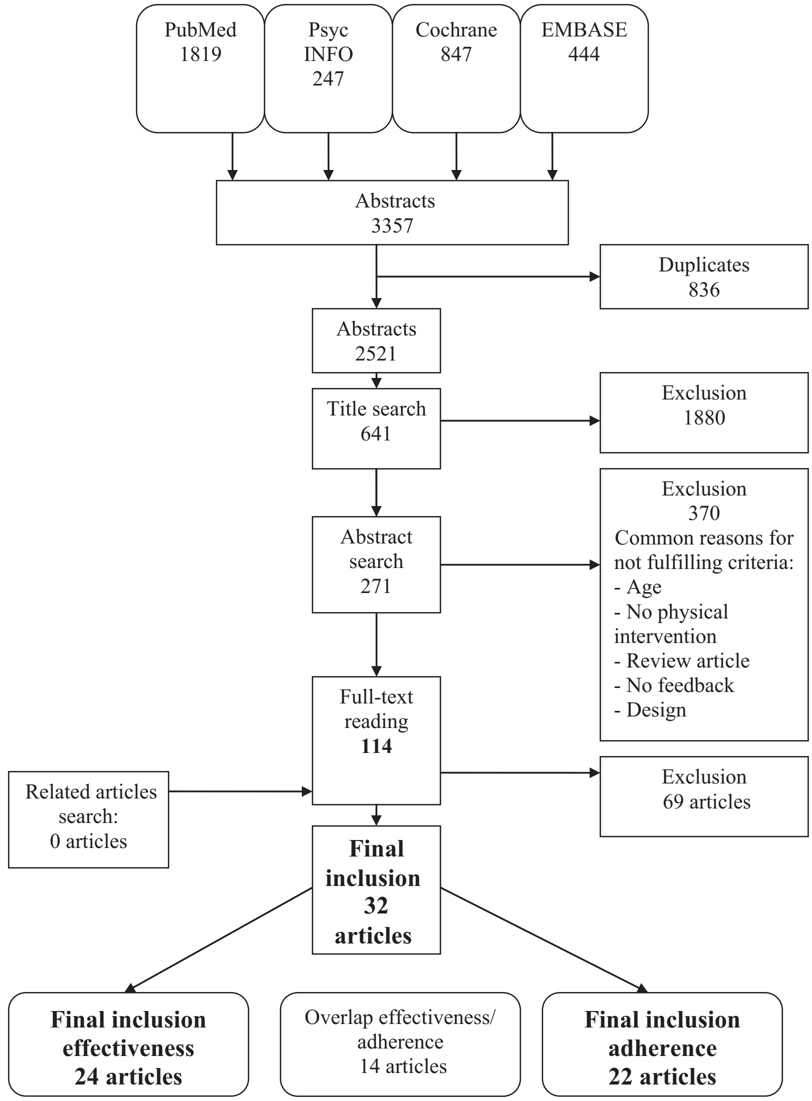


**Fig. 1.** Flow diagram study, selection procedure.

center-based exercising. This is reflected by the effectiveness of one study [41], which reported an SMD of −0.16.

### 3.2. Adherence in remote feedback strategies

Adherence was addressed in 22 studies [7,10,11,20,21,23–25,27–29,31,32,35,37,41,43–48]. Details on adherence are shown in Table 2. Adherence rates in intervention groups varied between 32.1 and 91%. Fourteen studies had a single-group design or did not report adherence rates in the control group. Five studies compared the intervention group to treatment as usual. Results show that adherence when providing remote feedback was higher than in the control groups. Three studies compared adherence in the remote contact group to adherence in exercising control groups without remote contact or general guidelines to increase physical activity [7,41,45]. One study reported that their intervention group exercising with a live connection with their instructor had a higher adherence than the group exercising at home without feedback, and adherence was comparable to a group exercising in supervised classes [41]. Another study reported a significantly higher adherence for their home-based exercising group using a text-messaging feedback strategy than for their home-based exercising group using a phone-contact feedback strategy (57.4 vs. 32.1% adherence) [10].

## 4. Discussion and conclusion

### 4.1. Discussion

This systematic review presents an overview of the literature reporting about the effectiveness on physical activity and capacity of remote feedback used in home-based physical activity interventions for older adults with or without medical conditions. In addition, an inventory on adherence was taken. Frequent, non-frequent and direct contact all seem beneficial to effectiveness, but the strength of evidence varies between these categories.

Frequent contact, mostly once a week, is often used for remote contact in home-based physical activity programs. It seems that frequent contact is equally effective or has a larger effect than care as usual or no intervention, and is equally effective as (supervised) exercise without feedback. The five non-frequent remote contact interventions show consistent positive results on several physical capacity measures [35,38,39]. It can be concluded that non-frequent contact is more effective than care as usual or no intervention, and equally effective as supervised exercise without feedback. Strong evidence based on three studies indicates that direct remote contact provides positive results on physical activity and capacity measures comparable to supervised training. Direct remote contact is more effective than care as usual or no

**Table 2**
Characteristics of included studies.

| Reference | Design | Study size (mean age); patient group | Characteristics of exercise program | Feedback technology and frequency | Outcome measures | PEDro | Results | E/A[a] |
|---|---|---|---|---|---|---|---|---|
| Frequent contact (effectiveness) | | | | | | | | |
| Courneya [20] | RCT | 102 (6113/5992); colorectal cancer survivors | **Duration:** 16 weeks **Intervention:** Moderate-intensity exercise at home 3-5× pw, 20–30 min **Control group:** Not doing any structured exercise | Weekly phone calls report level of exercise, for adherence | Flexibility/resting heart rate/ adherence | 7 | Flexibility similar, non-sign. increase in both groups. Resting heart rate similar, non-sign. decrease in both groups. Adherence in intervention group 75.8% | E + A |
| Haines [21] | RCT | 53 (80.9/80.5); family caregivers | **Duration:** 8 weeks **Intervention:** "Kitchen Table Exercise Program" Lower-limb strength and balance exercises. 6 types with 6 levels **Control group:** No intervention | Weekly phone calls to provide advice, encouraging. Control group nothing | Physical capacity/ compliance | 7 | After 2 months, no sign. differences in physical capacity between intervention and control group. 15 out of 19 participants attempted program at home at least once during week 1, with 12 completing all 6 exercise types at least twice. Similar in week 2 but compliance dropped fast during weeks 3–8. | E + A |
| Arthur [22] | RCT | 242 (64.2/62.5); post-CABG surgery | **Duration:** 6 months **Intervention:** 60 min aerobic training (walking), 5× pw **Control group:** Hospital-based supervised training | Biweekly telephone calls; 2× 1 h exercise consultation | Peak $VO_2$/resting heart rate/peak heart rate/peak METs | 6 | Sign. increase in peak $VO_2$ and peak METs in both groups after 6 months. Similar sign. reductions in resting heart rate in both groups. Peak heart rate sign. increase in supervised group, almost sign. increase in home group | E |
| Griffith [22] | RCT | 126 (60.2); cancer patients | **Duration:** Variable, mean 12.83 weeks **Intervention:** Individualized walking 20–35 min, 5× pw **Control group:** Usual care | Biweekly telephone calls. Intervention and control group | Peak $VO_2$/ compliance | 6 | Patients who exercise during cancer treatment maintain or increase cardiorespiratory fitness. Adherence in intervention group 67.6%, in control group 77.6% | E + A |
| Jan [24] | RCT | 53 (58.8/59.3/57); unilateral hip replacement | **Duration:** 12 weeks; 50–60 min daily **Intervention:** Daily; hip flexion ROM exercises, isotonic strengthening exercises, additional strengthening of hip adductors; 30-min walk at comfortable speed **Control group:** No intervention | Weekly phone call, to solve problems | Walking speed/ compliance | 6 | Subjects in the exercise-high compliance (>50%) group showed sign. improvement in free and fast walking speed. Improvements sign. larger than in the exercise-low compliance and control groups. Adherence problematic due to program intensity | E + A |
| Jette [25] | RCT | 215 (75.4/74.6); older adults with disabilities | **Duration**: 6 months **Intervention**: 3× pw, 35-min videotaped program using Therabands for individualized resistance **Control group**: Waiting list | Phone support to monitor progress. Calls for questions or problems | Strength/balance/ TUG/Adherence | 6 | Sign. more improvement in tandem gait in intervention group. Adherence 89% of recommended sessions | E + A |

**Table 2** (*Continued*)

| Reference | Design | Study size (mean age); patient group | Characteristics of exercise program | Feedback technology and frequency | Outcome measures | PEDro | Results | E/A[a] |
|---|---|---|---|---|---|---|---|---|
| Regensteiner [26] | CT | 20 (65/64); intermittent claudication | **Duration:** 3 months **Intervention:** Hospital-supervised training group **Control group:** Home-based walking. 3× pw as rapidly as possible 35 min, up to 50 min later in program | Weekly calls to record # walking sessions and time, and give support and encouragement. | Peak $VO_2$ | 6 | Peak walking time, sign. increase in all patients. Only supervised group sign. increase in peak $VO_2$ | E |
| Windsor [27] | RCT | 66 (69.3/68.3); cancer | **Duration:** 4 weeks **Intervention:** 3×/w 30 min. moderate-intensity walking **Control group:** Normal advice | Weekly phone contact, wearing heart rate monitor before/during activity | Shuttle test/ adherence | 6 | Intervention group sign. increase in shuttle-run test, control group deteriorates. Control group non-sign. decline in adherence, intervention group small non-sign. increase | E + A |
| Oka [28] | RCT | 40 (30–76); heart failure | **Duration:** 3 months **Intervention:** Endurance and resistance exercise 3–5 days/week 20–30 min. with rising intensity, resistance and walking **Control group:** No exercise | Phone weekly | Peak $VO_2$/METs/ adherence | 5 | Minimal changes in physical fitness levels. No sign. differences in peak $VO_2$ between the two groups. Average exercise varied between 75 and 110% for the different physical aspects of the program. Adherence decreased over the 12 weeks | E + A |
| Oka [29] | RCT | 24 (30–76); heart failure | **Duration:** 3 months **Intervention:** 2×/week resistance 40–60 min.; walking at home **Control group:** Usual care | Phone weekly | Peak $VO_2$/METs/ adherence | 5 | No sign. differences in exercise capacity measures between the groups. Average exercise varied between 75 and 110% for the different physical aspects of the program | E + A |
| Opdenacker [7] | CT | 186 (66.3/70.0/67.9); Sedentary but healthy older adults | **Duration:** 11 months **Intervention:** Individualized home-based program for strength, endurance, flexibility, posture and balance **Control group:** Structured supervised group sessions, 3×/week. 2ND **Control group:** Measurements only | Initially once every 2 weeks, later monthly phone calls | Peak $VO_2$, muscular fitness, arm curl test, chair stand test, vertical jump, body composition | 5 | Decrease in cardiorespiratory fitness, muscular fitness and functional performance at follow-up in the structured group but not in the lifestyle intervention group. Lifestyle intervention group showed long-term improvements in functional performance. Adherence: 78.3% to the prescribed exercises in the lifestyle intervention group and 80% in the structured group | E + A |
| Pinto [30] | RCT | 130 (63.6); Cardiac rehabilitation patients | **Duration:** 6 months **Intervention:** Exercise counseling **Control group:** Contact control | Phone call weekly first 2 months, biweekly during months 3–4, monthly last 2 months. Based on Transtheoretical Model and Social Cognitive Theory | 7-day physical activity recall (7-Day PAR)/ accelerometer data/Peak $VO_2$ | 5 | Group differences in exercise at 6 months were non-significant. Peak $VO_2$ was also non-significantly different at 6 months | E |
| Senuzun [31] | RCT | 60 (54.7); heart failure | **Duration:** 12 weeks **Intervention:** 3× pw 45–60 min. session of home-based exercises **Control group:** No exercise | Phone every 2 weeks to provide self-efficacy enhancing program | Exercise capacity/ adherence | 5 | Exercise capacity, sign. improved in intervention group compared to control group. Mean adherence 91% in intervention group | E + A |

**Table 2** (*Continued*)

| Reference | Design | Study size (mean age); patient group | Characteristics of exercise program | Feedback technology and frequency | Outcome measures | PEDro | Results | E/A[a] |
|---|---|---|---|---|---|---|---|---|
| Brosseau [32] | RCT | 80 (58.8/58.5); cardiac surgery | **Duration:** 8 weeks<br>**Intervention:** Home program, low-intensity aerobic training; 1.5–4 METs<br>**Control group:** General guidelines to enhance PA progressively | Phone calls 2× 1 st week, once 2nd week, every two weeks on weeks 3–8 | 6-Minute walking distance (6MWD); compliance, adherence | 4 | No sign. differences in aerobic capacity or peak rate-pressure product between intervention and control group at 8 weeks. Frequency and duration of exercising relatively compliant, intensity not. Intervention has no more effect than on control group. Low exercise intensity | E + A |
| Nocera [33] | CT | 20; Parkinson's patients | **Duration:** 10 weeks<br>**Intervention:** Parkinson's patients performing balance-training exercises<br>**Control group:** No exercise, healthy older adults | One instruction visit, weekly phone calls | Postural control | 4 | At post-test, sign. improvement in PD balance scores and no sign. differences between PD group and healthy control group | E |
| Oh [34] | RCT | 23 (64.8/66.8); lung patients | **Duration:** 8 weeks<br>**Intervention:** 5×/day; inspiratory muscle training, upper and lower extremity exercises, relaxation, phone session<br>**Control group:** Educational advice | 2 phone calls/week | 6MWD | 4 | Sign. increase in exercise group and sign. decrease in controls in 6MWD at 8 weeks | E |
| Non-frequent contact (effectiveness) | | | | | | | | |
| Courtney [35] | RCT | 128 (78); acute medical admission | **Duration:** 24 weeks<br>**Intervention:** Muscle-stretching, balance training, walking, muscle strengthening<br>**Control group:** Routine care Feedback on general exercise, progress, adherence and availability/ support | Weekly phone calls 4 weeks after discharge, then monthly follow-up for 5 months | Walking impairment questionnaire (WIQ)/adherence | 7 | Sign. interactions in time and group for subscale WIQ walking speed, walking distance, climbing stairs: intervention group greater improvement than controls. Greatest effects seen 4 weeks after discharge. Moderate level of adherence to exercise program, 53% (n531) of the intervention group undertaking their program all the time or nearly every day. | E + A |
| Morey [36] | RCT | 641 (65–91); long-term cancer survivors | **Duration:** 12 months<br>**Intervention:** Daily 15 min. strength and 30 min. endurance training, including dietary advice<br>**Control group:** Waiting list | Phone first weekly, then every 2 weeks, then monthly. To overcome barriers, enhance self-efficacy | PA (duration and frequency of strength and endurance training) | 7 | PA increased sign. in intervention group. Diet and exercise intervention more effective than waiting-list controls | E |
| King [37] | RCT | 100 (62.2/63.3); older adult family caregivers | **Duration:** 12 months<br>**Intervention:** Home-based phone-supervised, moderate-intensity exercise training. Four 30–40 min. sessions/week brisk walking<br>**Control group:** Attention control group (food habits) | Regular phone contact | PA self-reported/ adherence | 5 | Compared with control group, intervention group showed sign. improvements in total energy expenditure. Adherence in intervention group 73.4% mean across 12 months | E + A |

**Table 2** (*Continued*)

| Reference | Design | Study size (mean age); patient group | Characteristics of exercise program | Feedback technology and frequency | Outcome measures | PEDro | Results | E/A[a] |
|---|---|---|---|---|---|---|---|---|
| Kodis [38] | Retrosp | 713 (61); coronary artery disease | **Duration:** 6 months **Intervention:** Unsupervised at home **Control group:** Supervised exercise | Phone occasionally | Peak $VO_2$/peak METs | 4 | Comparable sign. increase in peak $VO_2$ and peak METs in both groups | E |
| Savage [39] | | 21 (66.3/66.1/66.4); intermittent claudication | **Duration:** 12 weeks **Intervention:** Home 3× p/w, walking to the point of intense pain, resting, then continuing to a total of 15 min. walking. Grad. increase to 40 min **Control group:** Supervised on-site structured program | Phone once a month to discuss the program | Peak $VO_2$ | 4 | Non-sign. difference in peak $VO_2$ in intervention group, comparable to supervised program | E |
| Direct remote contact (effectiveness) | | | | | | | | |
| Weinstock [40] | RCT | 1650 (70.9/70.8); diabetes | **Duration:** Variable **Intervention:** Video conference with diabetes educator every 4–6 weeks **Control group:** Usual care | Video-conferencing | PA | 6 | PA declined sign. less over years in telemedicine group compared to control group | E |
| Wu [41] | RCT | 64 (76.1/74.1/75.9); seniors at risk for falls | **Duration:** 15-weeks **Intervention:** 24-form Tai-Chi, 3×/week at home **Control group:** Home unsupervised group and a group at center; same Tai-Chi routines | Live feedback during exercise (Doc-Box) | TUG/SLS/body sway/compliance | 6 | Intervention group and center-based control group sign. higher improvement in TUG compared to unsupervised controls. Intervention group sign. improvement in SLS. Intervention and center-based group sign. higher compliance than unsupervised group (69 vs. 71 vs. 38%) | E + A |
| Ades [42] | Non-random | 133 (56/58); cardiac rehabilitation | **Duration:** 3 months **Intervention:** Progressive individualized monitored program at home 40–50 min. per session **Control group:** Center-based exercise. Both groups education program | Direct phone contact during exercise sessions | Peak $VO_2$ | 4 | Peak $VO_2$ similar sign. rise in both groups. Submaximal $VO_2$ not altered in either group | E |
| Adherence only articles (all contact strategies) | | | | | | | | |
| Castro [43] | RCT | 100 (6273); women caring for relatives with dementia | **Duration:** 12 months **Intervention:** 4×/wk for 6 weeks gradually increasing exercise, phone calls to monitor for 12 months afterwards. Most persons do brisk walking **Control group:** Nutritional advice through phone calls matched with exercise group | Non-frequent contact. 15 phone calls for 12 months, using counseling strategies from social cognitive theory | Adherence | – | Adherence exercise group 74% of prescribed sessions. More contacts directly related to higher adherence | A |

**Table 2** (*Continued*)

| Reference | Design | Study size (mean age); patient group | Characteristics of exercise program | Feedback technology and frequency | Outcome measures | PEDro | Results | E/A[a] |
|---|---|---|---|---|---|---|---|---|
| Courneya [44] | RCT | 102 (60.3/61.1/59.9); colorectal cancer survivors | **Duration:** 16 weeks<br>**Intervention:** Cardiovascular and flexibility exercises, self-chosen exercise, 3–5× pw 20–30 min<br>**Control group:** Not doing any structural exercise | Frequent contact. Weekly telephone calls to all participants (adherence/barriers). | Adherence | – | Adherence 75.8% in exercise group and 51.6% in controls, in moderate/strenuous exercise. Sign. difference, but for other exercise intensities non-sign. difference between adherences | A |
| Degischer [45] | CT | 59 (68.8); intermittent claudication | **Duration:** 3 months active training and 3 months follow-up<br>**Intervention:** Non-structured home-based physical training; walk at least 1 h a day outdoors<br>**Control group:** Structured supervised PAD rehabilitation | Frequent contact. Home: phone weekly to offer advice | Compliance | – | Compliance based on logbook and phone interviews. No patient omitted the training for >14 days of the active training period; five patients (23.8%) were noncompliant for >7 days but <14 days; seven patients (33.3%) were non-compliant for <7 days during 3-month training period. | A |
| Harada [10] | RCT | 35 (78/69.9/76/65); male veterans | **Duration:** 11 weeks<br>Intervention groups: "Exercise at least 30 min each day", reinforced by either Health Buddy (HB) or telephone calls<br>**Control group:** – | Frequent contact. Daily feedback by HB device or phone contact | Adherence | – | Adherence higher in text-messaging group than in phone group (sign.: 57.4 vs. 32.1% outpatient; non-sign.: 77 vs. 81% inpatient) | A |
| Papaioannou [46] | RCT | 74 (60 min); osteoporosis | **Duration:** 12 months<br>**Intervention:** 3× p/w 60 min., stretching, strength training and aerobics during the day<br>**Control group:** No exercise | Frequent contact. Monthly in first 6 months, follow-up phone calls every 2 weeks | Adherence | – | Adherence 62% in home intervention group | A |
| Ruhland [47] | Intervention-control | 28 (56.2); chronic peripheral neuropathy | **Duration:** 6 weeks<br>**Intervention:** Strengthening with Theraband (progressive) 10 reps each day, aerobic conditioning incl. walking or cycling 10–20 min<br>**Control group:** No exercise | Non-frequent contact. Phone weeks 1 and 5, to monitor progress and encourage adherence | Adherence | – | 91% of the possible exercise days were logged in as completed | A |
| Sashika [48] | CT | 23 (63.4); THA | **Duration:** 6 weeks; 15–20 min. daily<br>**Intervention:** ROM and muscle-strengthening exercise (2 different groups)<br>**Control group:** No exercise | Frequent contact. Phone contact every 2 weeks | Compliance | – | Compliance with home program 70% | A |
| Wu [11] | Single group design | 17 (81); independently living seniors | **Duration:** 15 weeks<br>**Intervention:** Aerobic exercise Tai Chi Quan; 3× p/w, 30–60 min<br>**Control group:** – | Frequent contact. Phone consultation | Compliance | – | Average attendance rate 78% | A |

Legend: p/w = per week; sign. = significant; ROM = range of motion.

[a] E: article included in effectiveness evaluation; A: article included in adherence evaluation.

intervention, and equally effective as exercise without direct remote contact.

The above-mentioned results are in line with literature pointing to the positive influence of encouragement and feedback on physical activity programs, yet some additional remarks have to be made [8]. First, it seems non-frequent contact strategies might be as effective as frequent contact strategies in raising physical activity or physical capacity. This is not in line with literature stating that a higher contact frequency is directly related to higher adherence [41,43] or effectiveness. However, it must be mentioned that especially in the frequent contact group the heterogeneity in studies was large. Studies varied widely in design, outcome measures and target groups. This heterogeneity is probably the cause of the conflicting results for effectiveness in the frequent contact group: although it seems as if non-frequent might be more effective than direct feedback, more research is needed to confirm this outcome. Secondly, direct remote contact with a coach looks a promising alternative for center-based supervised exercising. Additional benefits of home-based exercise is that it lowers barriers of transportation to exercise facilities and can be comfortably integrated into the lifestyle of older adults, making it easier to keep up for a longer period. Direct supervision during home-based exercising is therefore a good alternative to supervised on-site exercising. Finally, it should be mentioned that only nine out of 24 studies included in the effectiveness evaluation report use an alternative exercise program as a control group [7,22,26,32,35,38,39,41,42].

In addition to the systematic evaluation of effectiveness, adherence to home-based physical activity programs using remote feedback was inventoried non-systematically. Adherence to interventions using remote feedback seems mostly acceptable-to-good, with rates in intervention groups varying between 32.1 and 91%. Several interventions using frequent feedback contact report larger adherence than their control groups, or adherence comparable to supervised exercise interventions. In the literature, supervised on-site physical activity programs have been depicted as being more effective than non-supervised programs [9]. Based on our inventory of adherence, direct remote contact during home-based exercising seems a good alternative to supervised onsite exercising. One study compared text messaging to a phone strategy [10]. Text messaging led to a significantly higher adherence than the phone strategy, which seems to be an interesting contact strategy for future use.

The contacts content in all 32 studies was inventoried. Even though use of a remote feedback strategy in studies is often a means to an end instead of a primary goal to be studied, in several articles the remote contact strategy was explicitly grounded in theory. In five studies the contacts were reported to be integrated into a counseling or motivational strategy based on theoretical background and findings from the literature [25,31,35,36,44]. Interestingly, goal-setting was used as part of a counseling or motivational strategy in three studies [25,31,35]. Social-cognitive strategies to enhance self-efficacy were used in two studies [29,31,36]. Eleven other studies mentioned using individualized feedback, education or encouragement [10,21,22,24,26,27,29,30,34,37,43]. The studies using a direct remote contact strategy did not report using specific theory-based motivational or coaching strategies [40–42]. Overall it can be concluded that the surplus value of theory-based remote feedback could not be determined in this review. This was mainly due to a lack of comparison between programs that integrated theory-based remote feedback and programs that did not. There are some indications that frequent or non-frequent remote contact combined with a counseling or motivational strategy could positively influence effectiveness and adherence, but more research is necessary.

Finally, it should be remarked that there are some limitations to this review. First, studies that implicitly used a remote feedback strategy might be missing, since they are not recognized by our search strategy. However, since reference lists of included studies were scanned for relevant studies, the probability of missed studies is small. In this respect, mixed remote contact designs are not included either, since studies with a substantial number of live visits were not allowed. A point of potential bias is the language selection, as only studies reported in the English, Dutch and German languages were included. Twelve articles were excluded due to this restriction, but based on the English abstracts it was concluded that these articles did not meet our inclusion criteria regardless of language. Language restrictions thus did not influence the main conclusions. In addition, no articles written in Dutch or German fulfilled the inclusion criteria, so only articles written in English were included in the final article group. This review may also have a potential publication bias, as results of relevant studies might not have been published. Since the vast majority of studies failed to report sufficient data to calculate SMDs, it was not possible to conduct a quantitative analysis. We therefore used qualitative levels of evidence to summarize the results. Use of a best-evidence synthesis is a next-best solution and is a transparent method commonly applied when statistical pooling is not feasible [14].

### 4.2. Conclusions

Evidence for effectiveness of remote contact in home-based physical activity programs for older adults on enhancing physical activity varies from conflicting in frequent-contact strategies to strong in non-frequent and direct remote contact strategies. Direct remote contact looks particularly promising for enhancing effectiveness. Adherence to interventions using remote feedback seems acceptable to good. The studies in this review primarily used telephone contact strategies and showed little use of recent communication technology such as direct video contact. The studies seldom included explicit descriptions of the content of motivational or counseling strategies.

### 4.3. Practice implications

Remote feedback in home-based physical activity programs for older adults seems promising for enhancing effectiveness on physical activity and capacity. Modern information and communication technology offers several attractive options for providing remote feedback, and older people's skills to use such technology seem to be increasing. In 2006, 33% of Dutch 65- to 75-year-olds did not have any computer skills [49] and by 2010 this percentage was down to 25%; the percentage of older adults with computer skills thus grew from 12 to 19% [49]. Cell phone use in older adults is also rising [49]. In 2011, 58% of U.S. older adults over age 65 owned a mobile phone [50]. In addition, use of computers and cell phones is widely spread among middle-aged individuals. Use of computers and mobile phones will therefore probably keep rising among older adults. Direct remote contact during exercising could be a (cost)-effective option to replace supervised training, if participants know how to work with the technology. However, more research needs to be done on feasibility and (cost)-effectiveness for use of modern technology in home-based physical activity programs for older adults.

## Conflict of interest

The authors declare that they do not have any competing interests.

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