New for old
Geraedts, Hilde

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2017

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
Chapter 2

Remote feedback in home-based physical activity interventions for older adults: a systematic review

Geraedts H.A.E.
Zijlstra A.
Bulstra S.K.
Stevens M.
Zijlstra W.

Chapter 2

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.

Results
3087 articles were identified: 22 studies met the inclusion criteria for systematic effectiveness evaluation and 21 for adherence inventory. Three categories of contact were identified: frequent or non-frequent contact and direct remote contact during exercising. Evidence for positive enhancement of physical activity and capacity was conflicting in studies using frequent contact and strong in studies using non-frequent contact or direct remote contact during exercising. Adherence rates for home-based interventions varied between 32.1 and 91%.

Conclusion
Results imply with varying strength that frequent and non-frequent remote contact in home-based physical activity programs enhance effectiveness of physical activity and capacity measures. In particular, direct remote contact during exercise looks promising for enhancing effectiveness. Adherence in interventions using remote feedback seems acceptable to good.

Practice Implications
Remote feedback is a promising direction in an older population getting increasingly used to new technology.

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 this recommendation, 42-90% of Dutch and 21-40% of American older adults are 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]. In this review, home-based physical activity interventions are defined as structured physical activity interventions exclusively situated in the participant’s own home, aimed at raising their (daily) physical activity or capacity. 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.

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. For instance, Wu et al. used video conferencing in a home-based physical activity program. All subjects were exercising in their own homes while simultaneously being connected through video to an instructor who could see, instruct and coach the exercising participants, hence allowing direct remote contact between coach and participants [10]. Messaging devices and internet-based strategies have also been reported [11,12]. 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.

Methods

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 2011. 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 telesupervision OR tele-supervision OR tele-rehabilitation OR rehabilitation OR tele-exercise OR tele-exercise OR tele-care OR tele-care OR tele-training OR tele-training 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.

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 or a third reviewer (WZ).

The following general inclusion criteria were formulated for study selection:

1. The study assesses a physical activity intervention program.
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 [13]. 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”.

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 [13]. Quality assessment was performed independently by two researchers (HG & AZ), and any disagreements were solved by a third researcher (WZ). 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 [14,15].
Table 2. Quality rating of the selected studies.

<table>
<thead>
<tr>
<th>Criteria of the PEDro scale</th>
<th>Quality rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External validity</strong></td>
<td></td>
</tr>
<tr>
<td>1. Eligibility criteria were specified.*</td>
<td></td>
</tr>
<tr>
<td><strong>Internal and statistical validity</strong></td>
<td></td>
</tr>
<tr>
<td>2. Subjects were randomly allocated to groups.</td>
<td></td>
</tr>
<tr>
<td>3. Allocation was concealed</td>
<td></td>
</tr>
<tr>
<td>4. The groups were similar at baseline on the most important prognostic indicators.</td>
<td></td>
</tr>
<tr>
<td>5. There was blinding of all subjects.</td>
<td></td>
</tr>
<tr>
<td>6. There was blinding of all therapists who administered the therapy.</td>
<td></td>
</tr>
<tr>
<td>7. There was blinding of all assessors who measured at least one key outcome.</td>
<td></td>
</tr>
<tr>
<td>8. Measurements of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.</td>
<td></td>
</tr>
<tr>
<td>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”.</td>
<td></td>
</tr>
<tr>
<td>10. The results of between-group statistical comparisons are reported for at least one key outcome.</td>
<td></td>
</tr>
<tr>
<td>11. The study provides both point measurements and measurements of variability for at least one key outcome.</td>
<td></td>
</tr>
</tbody>
</table>

* Quality rating only includes items 2-11.

**Best-evidence synthesis**

After an initial screening of the selected articles it was decided that a qualitative rather than quantitative analysis of the results would be more appropriate, since the selected articles were heterogeneous in terms of testing procedures and outcome measures. Statistical pooling was therefore not possible and a best-evidence synthesis was used [14,15]. Quality assessment results of the studies were used to classify level of evidence. The best-evidence synthesis method identifies five levels of evidence:

- **Strong evidence**: generally consistent findings in multiple high-quality studies (≥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 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.

**Results**

The full selection procedure flow chart is shown in Figure 1. The search strategy identified 3087 articles. After duplicate removal, 2251 articles were left. After scanning their titles, 507 articles were included. Abstract reading resulted in 76 articles; after full-text reading of these, 30 articles were left for total inclusion. Three articles were excluded due to a PEDro score below 4 [16,17,18]. Twenty-two articles were finally included in the effectiveness evaluation. The agreement between raters on the 22 studies was 96%. The range of PEDro scores was between 4 and 7 with a median score of 6. Twenty-one articles were finally included in the adherence evaluation, exclusion being in most cases a lack of reporting on adherence.

![Figure 1. Flow diagram, Study selection procedure](image-url)
<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age); patient group</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro Results</th>
<th>Results</th>
<th>E/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courneya</td>
<td>RCT</td>
<td>102 (61.1); colorectal cancer survivors</td>
<td>Duration: 16 weeks</td>
<td>Intervention: Moderate-intensity exercise at home; 3-5x pw, 20-30 min.</td>
<td>Control group: Not doing any structured exercise</td>
<td>Weekly phone calls report level of exercise, for adherence.</td>
<td>Flexibility/ resting heart rate/ adherence</td>
<td>Flexibility similar, non-sign. increase in both groups. Resting heart rate similar, non-sign. decrease in both groups. Adherence in intervention group 75.8%</td>
</tr>
<tr>
<td>Haines</td>
<td>RCT</td>
<td>53 (80.9); family caregivers</td>
<td>Duration: 8 weeks</td>
<td>Intervention: “Kitchen Table Exercise Program”</td>
<td>Lower-limb strength and balance exercises; 6 types with 6 levels</td>
<td>Control group: No intervention</td>
<td>Weekly phone calls to provide advice, encouraging. Control group nothing.</td>
<td>Physical capacity/ compliance</td>
</tr>
<tr>
<td>Arthur</td>
<td>RCT</td>
<td>242 (64.2); post-CABG surgery</td>
<td>Duration: 6 months</td>
<td>Intervention: 60 min. aerobic training (walking), 5x pw</td>
<td>Control group: Hospital-based supervised training</td>
<td>Biweekly telephone calls; 2x 1h exercise consultation.</td>
<td>Peak VO₂/ resting heart rate/ peak heart rate/ peak METs</td>
<td>Sign increase in peak VO₂ 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.</td>
</tr>
</tbody>
</table>

Legend: p/w = per week; sign. = significant; ROM = range of motion
* E: article included in effectiveness evaluation; A: article included in adherence evaluation
<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age); patient group</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro</th>
<th>Results</th>
<th>E/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regenstein (1997)</td>
<td>CT</td>
<td>20 (65/64); intermittent claudication</td>
<td>Duration: 3 months</td>
<td>Intervention: Hospital-supervised training group</td>
<td>Control group: Home-based walking; 3x pw as rapidly as possible 35 min., up to 50 min. later in program</td>
<td>Weekly calls to record # walking sessions and time, and give support and encouragement.</td>
<td>Peak VO\textsubscript{2}</td>
<td>6</td>
</tr>
<tr>
<td>Windsor (2004)</td>
<td>RCT</td>
<td>66 (69.3/68.3); cancer</td>
<td>Duration: 4 weeks</td>
<td>Intervention: 3x/w 30 min. moderate-intensity walking</td>
<td>Control group: Normal advice</td>
<td>Weekly phone contact, wearing heart rate monitor before/ during activity.</td>
<td>Shuttle test/ adherence</td>
<td>6</td>
</tr>
<tr>
<td>Oka (2000)</td>
<td>RCT</td>
<td>40 (30-76); heart failure</td>
<td>Duration: 3 months</td>
<td>Intervention: Endurance and resistance exercise 3-5 days/week 20-30 min. with rising intensity, resistance and walking</td>
<td>Control group: No exercise</td>
<td>Phone weekly.</td>
<td>Peak VO\textsubscript{2}/ METs/ adherence</td>
<td>5</td>
</tr>
<tr>
<td>Oka (2005)</td>
<td>RCT</td>
<td>24 (30-76); heart failure</td>
<td>Duration: 3 months</td>
<td>Intervention: 2x/w 40-60 min.; walking at home</td>
<td>Control group: Usual care</td>
<td>Phone weekly resistance</td>
<td>Peak VO\textsubscript{2}/ METs/ adherence</td>
<td>5</td>
</tr>
<tr>
<td>Senuzun (2006)</td>
<td>RCT</td>
<td>60 (54.7); heart failure</td>
<td>Duration: 12 weeks</td>
<td>Intervention: 3x pw 45-60 min. session of home-based exercises</td>
<td>Control group: No exercise</td>
<td>Phone every 2 weeks to provide self-efficacy enhancing program.</td>
<td>Exercise capacity/ adherence</td>
<td>5</td>
</tr>
<tr>
<td>Brosseau (1995)</td>
<td>RCT</td>
<td>80 (58.8/58.5); cardiac surgery</td>
<td>Duration: 8 weeks</td>
<td>Intervention: Home program, low-intensity aerobic training; 1.5-4 METs</td>
<td>Control group: General guidelines to enhance PA progressively</td>
<td>Phone calls 2x 1st week, once 2nd week, every two weeks on weeks 3-8.</td>
<td>6-minute walking distance (6MWD); compliance, adherence</td>
<td>4</td>
</tr>
</tbody>
</table>

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

* E: article included in effectiveness evaluation; A: article included in adherence evaluation
<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age); patient group</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro</th>
<th>Results</th>
<th>E/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nocera (2009) [31]</td>
<td>CT</td>
<td>20; Parkinson’s patients</td>
<td>Duration: 10 weeks</td>
<td>Intervention: Parkinson’s patients performing balance-training exercises</td>
<td>One instruction visit, weekly phone calls</td>
<td>Postural control</td>
<td>4</td>
<td>At post-test, significant improvement in PD balance scores and no significant differences between PD group and healthy control group.</td>
</tr>
<tr>
<td>Oh (2003) [32]</td>
<td>RCT</td>
<td>23 (64.8/66.8); lung patients</td>
<td>Duration: 8 weeks</td>
<td>Intervention: 5 x/day; inspiratory muscle training, upper and lower extremity exercises, relaxation, phone session</td>
<td>2 phone calls/week</td>
<td>6MWD</td>
<td>4</td>
<td>Significant increase in exercise group and significant decrease in controls in 6MWD at 8 weeks.</td>
</tr>
<tr>
<td>Courtney (2011) [33]</td>
<td>RCT</td>
<td>128 (78); acute medical admission</td>
<td>Duration: 24 weeks</td>
<td>Intervention: Muscle-stretching, balance training, walking, muscle strengthening</td>
<td>Weekly phone call 4 weeks after discharge, then monthly follow-up for 5 months</td>
<td>Walking impairment questionnaire (WIQ)/adherence</td>
<td>7</td>
<td>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% (n=531) of the intervention group undertaking their program all the time or nearly every day.</td>
</tr>
<tr>
<td>Morey (2009) [34]</td>
<td>RCT</td>
<td>641 (65-91); long-term cancer survivors</td>
<td>Duration: 12 months</td>
<td>Intervention: Daily 15 min. strength and 30 min. endurance training, including dietary advice</td>
<td>Phone first weekly, then every 2 weeks, then monthly. To overcome barriers, enhance self-efficacy.</td>
<td>PA(duration and frequency of strength and endurance training)</td>
<td>7</td>
<td>PA increased sign. in intervention group. Diet and exercise intervention more effective than waiting-list controls.</td>
</tr>
</tbody>
</table>

Legend: p/w = per week; sign. = significant; ROM = range of motion  
* E: article included in effectiveness evaluation; A: article included in adherence evaluation
<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age); patient group</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro</th>
<th>Results</th>
<th>E/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>King (2002)</td>
<td>RCT</td>
<td>100 (62.2/63.3); older adult family caregivers</td>
<td>Duration: 12 months Intervention: Home-based phone-supervised, moderate-intensity exercise training. Four 30-40 min. sessions/week brisk walking Control group: Attention control group (food habits)</td>
<td>Regular phone contact. PA self-reported/ adherence</td>
<td>5</td>
<td>Compared with control group, intervention group showed sign. improvements in total energy expenditure. Adherence in intervention group 73.4% mean across 12 months.</td>
<td>E + A</td>
<td></td>
</tr>
<tr>
<td>Kosid (2001)</td>
<td>Retros.</td>
<td>713 (61); coronary artery disease</td>
<td>Duration: 6 months Intervention: Unsupervised at home Control group: Supervised exercise</td>
<td>Phone occasionally</td>
<td>Peak VO$_2$/ peak METs</td>
<td>4</td>
<td>Comparable sign. increase in peak VO$_2$ and peak METs in both groups.</td>
<td>E</td>
</tr>
<tr>
<td>Savage (2001)</td>
<td></td>
<td>21 (66.3/66.1/66.4); intermittent claudication</td>
<td>Duration: 12 weeks Intervention: Home 3x 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</td>
<td>Phone once a month to discuss the program.</td>
<td>Peak VO$_2$</td>
<td>4</td>
<td>Non-sign. difference in peak VO$_2$ in intervention group, comparable to supervised program.</td>
<td>E</td>
</tr>
</tbody>
</table>

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

* E: article included in effectiveness evaluation; A: article included in adherence evaluation

<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age); patient group</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro</th>
<th>Results</th>
<th>E/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weinstock (2011)</td>
<td>RCT</td>
<td>1650 (70.9/70.8); diabetes</td>
<td>Duration: Variable Intervention: Video conference with diabetes educator every 4-6 weeks Control group: Usual care</td>
<td>Video-conferencing</td>
<td>PA</td>
<td>6</td>
<td>PA declined sign. less over years in telemedicine group compared to control group.</td>
<td>E</td>
</tr>
<tr>
<td>Wu (2010) [10]</td>
<td>RCT</td>
<td>64 (76.1/74.1/75.9); seniors at risk for falls</td>
<td>Duration: Intervention: 15-week, 24-form Tai-Chi, 3x/ week at home Control group: Home unsupervised group and a group at center; same Tai-Chi routines</td>
<td>Live feedback during exercise (Doc-Box)</td>
<td>TUG/ SLS/ body sway/ compliance</td>
<td>6</td>
<td>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 higher compliance than unsupervised group.</td>
<td>E + A</td>
</tr>
</tbody>
</table>

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

* E: article included in effectiveness evaluation; A: article included in adherence evaluation
### Reference Design Study size (mean age); patient group

<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age); patient group</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro</th>
<th>Results</th>
<th>E/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ades (2000) [39]</td>
<td>Non-random</td>
<td>133 (56/58); cardiac rehabilitation</td>
<td>Duration: 3 months Intervention: Progressive individualized monitored program at home 40-50 min. per session Control group: Center-based exercise. Both groups education program</td>
<td>Direct phone contact during exercise sessions.</td>
<td>Peak VO2</td>
<td>4</td>
<td>Peak VO2 similar sign. rise in both groups. Submaximal VO2 not altered in either group.</td>
<td>E</td>
</tr>
<tr>
<td>Castro (2002) [40]</td>
<td>RCT</td>
<td>100 (62,73); women caring for relatives with dementia</td>
<td>Duration: 12 months Intervention: 4x/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</td>
<td>Non-frequent contact. 15 phone calls for 12 months, using counseling strategies from social cognitive theory.</td>
<td>Adherence</td>
<td>-</td>
<td>Adherence exercise group 74% of prescribed sessions. More contacts directly related to higher adherence.</td>
<td>A</td>
</tr>
</tbody>
</table>

### Adherence only articles (all contact strategies)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age); patient group</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro</th>
<th>Results</th>
<th>E/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courneya (2004) [41]</td>
<td>RCT</td>
<td>102 (60,36/1,1/59,9); colorectal cancer survivors</td>
<td>Duration: 16 weeks Intervention: Cardiovascular and flexibility exercises, self-chosen exercise; 3-5x pw 20-30 min. Control group: Not doing any structural exercise</td>
<td>Frequent contact. Weekly telephone calls to all participants (adherence/barriers).</td>
<td>Adherence</td>
<td>-</td>
<td>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.</td>
<td>A</td>
</tr>
<tr>
<td>Degischer (2002) [42]</td>
<td>CT</td>
<td>59 (68,8); intermittent claudication</td>
<td>Duration: 3 months active training and 3 months follow-up Intervention: Non-structured home-based physical training; walk at least 1h a day outdoors Control group: Structured supervised PAD rehabilitation</td>
<td>Frequent contact. Home: phone weekly to offer advice</td>
<td>Compliance</td>
<td>-</td>
<td>Compliance based on logbook and phone interviews. No patient omitted the training for &gt;14 days of the active training period; five patients (23.8%) were noncompliant for &gt;7 days but &lt; 14 days; seven patients (33.3%) were non-compliant for &lt;7 days during 3-month training period.</td>
<td>A</td>
</tr>
</tbody>
</table>

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

* E: article included in effectiveness evaluation; A: article included in adherence evaluation
<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Study size (mean age; patient group)</th>
<th>Characteristics of exercise program</th>
<th>Feedback technology and frequency</th>
<th>Outcome measures</th>
<th>PEDro Results</th>
<th>E / A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harada (2010) [11]</td>
<td>RCT</td>
<td>35 ±8/9.8/96.65; male veterans</td>
<td>Duration: 11 weeks Intervention groups: “Exercise at least 30 minutes each day”, reinforced by either Health Buddy (HB) or telephone calls Control group: -</td>
<td>Frequent contact. Daily feedback by HB device or phone contact.</td>
<td>Adherence -</td>
<td>Adherence higher in text-messaging group than in phone group (sign.: 57.4 vs. 32.1% outpatient; non-sign.: 77 vs. 81% inpatient).</td>
<td>A</td>
</tr>
<tr>
<td>Papaioannou (2003) [43]</td>
<td>RCT</td>
<td>74 (60 min); osteoporosis</td>
<td>Duration: 12 months Intervention: 3x p/w 60 min., stretching, strength training and aerobics during the day Control group: No exercise</td>
<td>Frequent contact. Monthly in first 6 months, follow-up phone calls every 2 weeks.</td>
<td>Adherence -</td>
<td>Adherence 62% in home intervention group.</td>
<td>A</td>
</tr>
<tr>
<td>Ruhland (1997) [44]</td>
<td>Interv-control</td>
<td>28 (56.2); chronic peripheral neuropathy</td>
<td>Duration: 6 weeks Intervention: Strengthening with TheraBand (progressive) 10 reps each day, aerobic conditioning incl. walking or cycling 30-20 min. Control group: No exercise</td>
<td>Non-frequent contact. Phone contact every 2 weeks.</td>
<td>Adherence -</td>
<td>91% of the possible exercise days were logged in as completed.</td>
<td>A</td>
</tr>
<tr>
<td>Sashika (1996) [45]</td>
<td>CT</td>
<td>23 (63.4); THA</td>
<td>Duration: 6 weeks; 15-20 min, daily Intervention: ROM and muscle-strengthening exercise (2 different groups) Control group: No exercise</td>
<td>Frequent contact. Phone contact every 2 weeks.</td>
<td>Compliance -</td>
<td>Compliance with home program 70%.</td>
<td>A</td>
</tr>
<tr>
<td>Wu (2006) [12]</td>
<td>Single group design</td>
<td>17 (81); independently-living seniors</td>
<td>Duration: 15 weeks Intervention: Aerobic exercise 3x p/w, 30-60 min. Control group: Aerobic exercise training on treadmill, 30-60 minutes</td>
<td>Frequent contact. Phone consultation.</td>
<td>Compliance -</td>
<td>Average attendance rate 78%.</td>
<td>A</td>
</tr>
</tbody>
</table>

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

* E: article included in effectiveness evaluation; A: article included in adherence evaluation
Effectiveness of remote feedback strategies

Twelve high-quality studies and 10 low-quality studies were included in the systematic effectiveness evaluation [10,19-39]. See Table 2 for quality scores. The frequent-contact group included eight studies rated high-quality (PEDro ≥ 6) [19-26] and six low-quality [27-32]. Findings were inconsistent so results provide conflicting evidence. Results imply that home-based physical activity programs with frequent contact have effects on physical capacity comparable to hospital-based programs and better results on physical capacity than usual care.

The non-frequent telephone contact group included five studies [33-37], two high-quality [33,34] and three low-quality [35-37]. The studies reported generally consistent findings, thus providing strong evidence. Home-based physical activity programs with non-frequent remote contact were equally effective in physical capacity measures as supervised exercise groups and more effective in enhancing physical activity and capacity measures than usual-care or non-exercise control groups.

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 [10,38] and one low-quality study [39] that report generally consistent findings and therefore provide strong evidence. Results indicate that direct remote contact during exercising provides positive results on physical capacity measures. Effects are comparable to supervised training on physical activity and capacity measures, and is more effective than unsupervised exercising.

Adherence in remote feedback strategies

Adherence was addressed in 21 studies [10,12,19-24,26-30,33,35-45]. Details on adherence are shown in Table 2. Adherence rates in intervention groups varied between 32.1% and 91%. Castro et al. reported that more contacts are directly related to higher adherence [40]. Wu et al. (2010) reported that their intervention group exercising with the 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 [10]. Harada et al. 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) [11].

Discussion and Conclusion

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 to home-based physical activity interventions for older adults using remote feedback was taken. Frequent, non-frequent and direct remote contact was used in 30 included studies. The studies identified in this review primarily use telephone contact strategies. Recent advances in technology provide new possibilities for remote contact such as direct video, cell phone and internet [10,11,12]. Frequent, non-frequent and direct contact all seem beneficial to effectiveness of home-based physical activity programs for older adults, 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 for older adults. Results in the 14 studies using frequent contact are conflicting though. Some studies show significant increases in physical capacity measures comparable to that in supervised training [21,25], but others show no significant results on physical capacity measures [27,28] or results comparable to watching-list controls [19,27,28]. The inconsistency in findings is probably caused by the wide variety of target groups, interventions and goals of the studies included. Overall, it can still be concluded that there is a trend toward a positive influence of frequent contact on effectiveness of physical capacity and activity measures in home-based physical activity programs for older adults. This is in line with literature pointing to the positive influence of encouragement and feedback on physical activity programs [8].

The five non-frequent remote contact interventions show consistent positive results on several physical capacity measures [33,36,37]. In two studies, results are comparable to results of supervised exercising [36,37]. Strong evidence indicates that non-frequent remote feedback can influence effectiveness of physical capacity in home-based physical activity programs for older adults. This is also in line with the literature [8].

Strong evidence based on three studies indicates that direct remote contact during exercising provides positive results on physical activity and capacity measures comparable to supervised training. Direct remote contact with a coach during exercising is identified as a positive influence on effectiveness with respect to physical activity and capacity measures of home-based physical activity interventions [10,38,39]. The results imply that home-based interventions with a direct remote feedback strategy can be as effective as center-based supervised exercising. Additionally, home-based exercises can be comfortably integrated into the lifestyle of older adults, making it easier to keep up for a longer period.

Although the results in this systematic evaluation show a positive trend, there are also some points that need to be critically evaluated. The number of articles included in the non-frequent and direct remote-contact groups is not extensive. Articles included in the evaluation of effectiveness varied widely in design, outcome measures and target groups. And even though similar outcome measures were addressed for the same physical capacity or activity determinant, several different questionnaires or tests were used. For instance, to determine physical activity self-report questionnaires are used as well as the number of exercise bouts completed. Also, only a limited number of studies reports use of an alternative exercise program with a control group. Still, even with this limited number of heterogeneous studies there is a clear trend in results indicating a positive influence of remote feedback on effectiveness of physical activity and capacity in home-based physical activity programs for older adults.

In addition to the systematic evaluation of effectiveness on physical activity and capacity, 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 on-site exercising. One study included in this review compared text messaging to a phone strategy in a home-based physical activity program [11]. Text messaging led to a significantly higher adherence than the phone strategy, which seems to be an interesting contact strategy for future use.

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 included articles the remote contact strategy was explicitly mentioned and grounded in theory. The content of contacts in all 30 included studies was inventoried. 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 [24,29,33,34,41]. Interestingly, goal-setting was used as part of a counseling or motivational strategy in three studies [24,29,33]. Social-cognitive strategies to enhance self-efficacy were used in two studies [28,29,34]. Ten other studies mentioned using individualized feedback, education or encouragement [11,20,21,23,25,26,28,32,35,40]. The three studies using a direct remote contact strategy did not report using specific theory-based motivational or coaching strategies [10,38,39]. The results suggest that frequent or non-frequent remote contact combined with a counseling or motivational strategy could positively influence effectiveness and adherence in home-based physical activity interventions for older adults, 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. There might be interesting studies using these mixed designs that have a supporting remote feedback strategy in addition to live visits. A point of potential bias is the language selection, as only studies reported in the English, Dutch and German languages were included. This review may also have a potential publication bias, as results of relevant studies might not have been published.

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.

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 communications 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 [46] and by 2010 this percentage was down to 25%; the percentage of older adults with computer skills thus grew from 12 to 19% [46]. Cell phone use in older adults is also rising [46]. In 2011, 58% of U.S. older adults over age 65 owned a mobile phone [47]. 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 possibility to replace supervised training, if participants know how to work with the technology.

Acknowledgements
This study was financially supported by ZonMw (program “Diseasemanagement chronische ziekten”; project number 40-00812-98-09014). The authors would like to thank R. Rose for her language revisions of the final manuscript. The authors would also like to thank D.G. Van Ittersum for her assistance in designing the search strategy.
References


