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Published in:
BMC Geriatrics

Publication date:
2020

Document Version
Peer reviewed version

Link to publication in ResearchOnline

Citation for published version (Harvard):

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Older adults’ preferences for, adherence to and experiences of two self-management falls prevention home exercise programmes: A comparison between a digital programme and a paper booklet

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Abstract

**Background:** Fall prevention exercise programmes are known to be effective, but access to these programmes is not always possible. The use of eHealth solutions might be a way forward to increase access and reach a wider population. In this feasibility study the aim was to explore the choice of programme, adherence, and self-reported experiences comparing two exercise programmes – a digital programme and a paper booklet.

**Methods:** A participant preference trial of two self-managed fall prevention exercise interventions. Community-dwelling adults aged 70 years and older exercised independently for four months after one introduction meeting. Baseline information was collected at study start, including a short introduction of the exercise programme, a short physical assessment, and completion of questionnaires. During the four months intervention period, participants self-reported their performed exercises in an exercise diary. At a final meeting, questionnaires about their experiences, and post-assessments, were completed. For adherence analyses data from diaries were used and four subgroups for different levels of participation were compared. Exercise maintenance was followed up with a survey 12 months after study start.

**Results:** Sixty-seven participants, with mean age 77±4 years were included, 72% were women. Forty-three percent chose the digital programme. Attrition rate was 17% in the digital programme group and 37% in the paper booklet group (p=.078). In both groups 50-59% reported exercise at least 75% of the intervention period. The only significant difference for adherence was in the subgroup that completed ≥75% of exercise duration, the digital programme users exercised more minutes per week (p=.001). Participants in both groups were content with their programme but digital programme users reported a significantly higher (p=.026) degree of being content, and feeling supported by the programme (p=.044). At 12
months follow-up 67% of participants using the digital programme continued to exercise regularly compared with 35% for the paper booklet (p=.036).

Conclusions: Exercise interventions based on either a digital programme or a paper booklet can be used as a self-managed, independent fall prevention programme. There is a similar adherence in both programmes during a 4-month intervention, but the digital programme seems to facilitate long-term maintenance in regular exercise.

Trial registration: ClinTrial: NCT02916849

Keywords: Accidental Falls; Aged; Aged, 80 and over; Digital health; eHealth; Exercise; Falls prevention; Independent Living; mHealth; Self-management

Background

Falls among the increasing older population is a growing problem in society globally, and actions to prevent falls is necessary. Exercise programmes have been shown to be important interventions for community-dwelling seniors to reduce both rate and risk of falls [1, 2]. Fall and fall related injuries lead to substantial health care costs, for example in 2015 the cost was estimated at $ 50 billion in the US [3]. Not only costs and physical injuries caused by falls have consequences, fear of falling and avoidance of activity may have implications for daily life and social isolation among older adults [4]. Also fear of falling could be reduced by exercise programmes [5].

Various home exercise programmes have shown efficacy in falls prevention. The LiFE study [6] that investigated exercises integrated in daily life, compared with a standard exercise programme, and a control group (gentle exercise) is one example that prevented falls. Another recognised programme is the home-based Otago Exercise Programme, used extensively across the world as an evidence-based falls prevention programme [7–9]. The original programme contains a paper-based booklet with balance and strength exercises and recommends regular walks, together with multiple home visits and phone calls to encourage
and motivate participants and to progress the exercises [10]. However, the ProAct65+ trial results show that when the level of motivational support and home visits is less than recommended, the adherence to home-based Otago Exercise Programme (using booklets) is poor [11] and only marginally better with the provision of a DVD with instructions [12]. In the UK, many commissioned services do not provide home visit or telephone support with the same frequency, but hand out the booklets presuming participants continue with the exercises and progress over time [13]. The static nature of paper-based exercise programmes increases the risk that the training routine will become dull and repetitive for the user. Evidence implies that there is a problem with uptake and adherence to exercise in the home setting [14].

According to a review by Sherrington et al. [15] fall prevention interventions that challenge balance and have a higher dose have larger effects. Therefore, adherence to the programme is important as regular practice is most effective [16]. In a systematic review of older adults’ adherence to technology-based exercise programmes, the majority commercially available gaming technology (exergaming = videogames providing physical and/or cognitive exercise) and supervised interventions showed high adherence [17]. Fall prevention exercise interventions using e-Health alternatives, with motivation and support tools, are being studied to discover if such fall preventive interventions can increase adherence. ActiveLifestyle [18, 19] evaluated two different versions of a tablet-based exercise application, one with extra social features, compared to a brochure-based programme over 12 weeks. The study showed higher adherence for the application with social features and both application programmes were used more than the paper programme. An ongoing study, Standing Tall [20] delivers a home-based exercise programme through a tablet and provide additional equipment for practice at home, which is compared with a control group with information only.

Our research group have, in collaboration with older adults, developed an application for a smartphone, tablet or computer which will guide the user to independently perform fall prevention exercises in their own environment [21]. The application Safe Step, a self-
managed programme, aims to support the user and increase adherence by presenting the exercises in ways that seniors could identify themselves with, providing behaviour change support and a virtual physiotherapist. As uptake and adherence to exercise is often down to preference, it is important to ascertain whether this application is appealing to older people compared to traditional home exercise booklets. The use of a digital programme may help reach the increasing number of older adults in need of fall prevention.

Little is known about adherence when participants use Otago exercise booklet without the support by home visits or follow-up calls, and longer-term adherence has been sparsely evaluated with e-Health solutions for fall prevention as well. Accordingly, the aim of this participant preference feasibility study was to explore older adults’ participation in a four-month self-managed fall prevention exercise intervention, comparing a digital exercise programme (DP) and a paper booklet (PB). We specifically aimed to describe the participant characteristics and distribution in relation to the self-selected choice of programme, attrition rate, adherence to the programme, experiences and self-reported effects after the intervention, as well as exercise maintenance at one year after study start. The need for individual technical support within the DP group was also studied.

Method

Study design

The study was performed to compare two groups using different self-managed exercise programmes (DP or PB). Furthermore, to find out if the new digital programme was feasible for self-management, among seniors accustomed to the use of apps, in a forthcoming large RCT. All participants chose their preferred type of programme, based on their personal preferences and access to technology, no technical devices were provided in this study. After an introduction meeting with pre-assessments the participants exercised independently over
four months and self-reported their exercise in an exercise diary. The intervention was completed with a final meeting after four months. Follow-up 12 months after study start was completed using a postal survey. An overview of the study can be seen in Figure 1. The study is registered in ClinTrial: NCT02916849.

Participants

Inclusion criteria were: ≥70 years old, living independently, able to rise from a chair and stand without support, experiences of deterioration in balance OR need to be more careful not to lose balance OR have experienced a fall the past year. Exclusion criteria were: doing physical exercise more than 3 hours/week, self-reported progressive disease that was likely to influence mobility, and cognitive difficulties. Status of cognitive condition was judged during the screening interview, if the person was able to answer questions satisfactorily, and able to converse about matters regarding the study, they were considered suitable to take part in the study. Participants were recruited at four different senior citizen organisations and at a health care centre. At the senior organizations, information about the project was presented by members of the research team, and contact details of seniors interested in taking part were collected. A research assistant then phoned them for a short interview to screen for suitability to take part. Recruitment at the health care centre was undertaken by a physiotherapist, occupational therapist, nurse, medical doctor or nurse’s aide, who had received an introduction about the programmes sufficient to give information to the potential participants. Participation in the study was voluntary and did not influence the further care of the patient. All participants chose their programme during the first recruitment contact.

Procedure

Independent of choice of programme, all participants attended an introduction meeting lasting about two hours, including a short presentation about accidental falls and fall prevention, introduction of the exercise programme, and pre-assessments. The respective
programme’s main structure, how to select exercises and fill out the exercise diary, and safety aspects during the sessions at home was explained, with opportunity to try some exercises and ask questions. The digital programme group got additional information about the log-in procedure, and how to use parts of the behaviour change support available in the application. Two physiotherapists from the research group led the meetings (LLO, MS), both with experience from the field of fall prevention exercise programmes. Thirteen groups of maximum eight persons met for the introduction meeting. Seven groups from senior citizen organisations had the introduction meeting at the university campus for participants and six were held at the health care centre. The majority of introduction meetings were separate for the DP and PB participants. However, from the health care centre few participants chose the DP, so 2/3 of these meetings were mixed, but the introduction of the actual exercise programme (DP and PB) was kept separate.

Scheduled interaction with the participants during the study was limited as the study focused on self-management of the programmes. A phone interview with all participants was done a few weeks after study start to identify any problems with the programme at an early stage. A help-line phone number was provided in case of encountering any problems while using the programme during the intervention. In order to monitor technical support for the digital program a record of contacts from DP users was kept. Observations by a physiotherapist and a human computer interaction engineer (LM, RJ) were performed with six participants using the DP in their home after approximately eight weeks. A monthly peer-mentor group meeting was held with half of the participants in DP group (recruited at senior citizen organisations), this was also by self-selected choice. These meetings were led by two seniors with a mentor role, together with one of the researchers (MS). Three different topics were discussed, one at each meeting: (1) Initial experiences, (2) Motivation for exercise, and (3) Establishment of lasting exercise routines. The researcher’s role at these meetings did not aim to give extra technical support.
Eight final meetings were held at the university campus and another three at the health care centre. Also participants that had withdrawn from the intervention, by notifying that they stopped exercising, were invited to attend the final meeting to give feedback on the programme.

*Exercise programmes*

Both programmes were based on exercises from the Otago Exercise Programme [10] but to provide a variety of exercises at diverse levels, the DP was enriched with both easier and more challenging exercises mainly inspired by the Falls Management Exercise Programme (FaME) [22]. The application for the DP was developed in co-creation with older adults taking their needs and preferences into account. Thus, the exercises are instructed in short video clips imaging older persons doing the exercises, and the user-interface is clean and uncomplicated [21]. The Additional File 1 provides an example of the application’s interface.

In the DP (Safe Step v1 web-based or mobile application) the user builds his or her own exercise programme by selecting one exercise from each of ten predetermined groups of exercises to improve strength, balance and gait/step ability. Each exercise group had several variants of exercises with different levels of difficulty provided by video clips with verbal instructions. The application also included behaviour change support with written motivational feedback from a virtual physiotherapist (computer generated pre-written messages, delivered according to the participants’ reported exercise), exercise planning and possibility to review the exercise diary, as well as examples on how to integrate exercises into daily activities and practice outdoors.

The PB contained the Otago exercises with drawings and written instructions. In order to help the participants build their programme, the exercises were divided in two sections with strength or balance exercises. Each section was further arranged into three different levels of difficulty with was a modification from the Otago Home Exercise Programme Booklet.
Participants were instructed to select five exercises from each section to build a programme of ten exercises. Additional exercises for warm-up and stretching included in the booklet were not considered part of the programme’s ten exercises.

In the Supplementary Table 1, Template for Intervention Description and Replication (TIDieR) checklist, a more detailed description of the interventions can be found, Additional File 2.

**Exercise self-management**

Participants composed their own programme and exercised independently throughout the four months intervention, directed by material in the programmes and information given at the introduction meeting. Independent of which programme, all participants were asked to choose exercises that they experienced challenging but not too difficult to perform. For balance exercises this meant feeling unstable but without losing balance, and for strength exercises feeling a strain in the muscle but still able to complete the suggested number of repetitions. They were also advised to select new exercises to progress when an exercise became too easy, or to modify if they felt that the exercise they chose became too challenging. The recommendations were to exercise 30 minutes at least three times per week, according to instructions in the Otago Exercise Programme [10].

**Data collection**

Baseline information to describe participants was collected at the introduction meeting with a study specific questionnaire about: age, sex, living condition, education level, fall history, use of walking-aids, self-reported health, and access to technology devices. Activity level was measured with the Saltin-Grimby Physical Activity Level Scale (SGPALS) that also assimilates household activities [23]. Assessment of balance and functional strength was completed using the Short Physical Performance Battery (SPPB) with a maximum score of 12 for the best performance [24], assessed by a physiotherapist blinded to group allocation. Self-
rated balance confidence was measured using a translation of the Activities-specific Balance
Confidence Scale (ABC), rating from 0-100% for 16 activities [25] and a higher score means
better confidence. Attitudes to Falls Related Interventions (AFRIS) was determined by a form
with six translated statements about the attitude to the programme, to grade if agreed or not on
a scale 1-7 to each statement [26], a higher score means a more positive attitude.

Exercise diaries were filled out by the participants over the four months intervention. The
exercise diary for the DP allowed self-reporting of: date, which of the predetermined
exercises were done and time spent on the practice. The digital diary allowed self-report of
exercise once per day, information was stored in a database, from which researchers received
data electronically on a monthly basis. The exercise diary for the PB group consisted of a
monthly paper sheet, with rows for daily exercise reports, containing the same information as
in the DP diary. It was returned in pre-paid envelopes at the end of each month. All diaries
were reviewed monthly by the first author (LM), and if there was no data or the data was
uncertain the participant was contacted by phone.

A questionnaire developed for this study was answered by the participants at the final
meeting. The questionnaire dealt with their experience of using the programme and perceived
effects. It had three parts: (1) eleven statements where participants were asked to answer on a
Likert type scale from 1 = strongly disagree to 5 = strongly agree (as example “I’m satisfied
with the programme I used” or “I notice improved strength in my legs”), (2) two multi-answer
questions about positive and negative effects, and (3) further questions about any falls while
performing the exercises, if they would recommend the programme to others and if they were
going to continue with the programme. If participants did not attend the final meeting the
questionnaire was sent out by mail with a pre-paid envelope as their opinions were considered
important. Participants that withdrew from the intervention were presented with the option to
take part in this questionnaire.
Finally, 12 months after study start a short survey was sent out with a pre-paid envelope to the participants that completed the study and took part in the final meeting (n=45). The aim was to investigate if they continued with the programme, or if not, the reasons why and if they planned to restart.

**Analysis**

Differences between groups (based on choice of programme) for baseline characteristics were analysed using Chi-square test (Fisher’s exact test if expected count were <5), Student’s t-test or Mann-Whitney U-test depending on variable. The activity level of the SGPALS was dichotomized into groups of being inactive (level 1-2) or active (level 3-6) using the same method as Äijö et al. [27]. Withdrawal was noted when participants informed that they stopped exercising with the programme and attrition rate was defined as the proportion of participants that withdraw.

For adherence analyses, the first 16 weeks of self-reported exercise were used. Adherence was described according to guidelines by Hawley-Hague et al. [28] for older adults participating in exercise classes. Their recommendation is to report four types of adherence: completion, attendance, duration, and intensity. We considered two of those to be relevant to our self-management exercise programme: completion, and exercise duration. Four subgroups were created to compare adherence for the DP and the PB with the following definitions:

1. Enrolled, everyone that started the intervention.
2. Completed study, all participants that did not explicitly withdraw from the exercise programme, independent of the degree of participation.
3. Exercise completion $\geq 75\%$ of the weeks, participants that self-reported exercise at least one session per week for 12 of the 16 weeks.
4. Exercise duration ≥75%, participants that self-reported at least 75% of the recommended 90 minutes of exercise per week (at least in total 1080 minutes over 16 weeks).

For each participant, the mean number of minutes and sessions exercised per week were calculated for each week, until the participants stopped reporting to allow for short lapses during the intervention.

Many studies report adherence as percentage of the intended number of sessions over the intervention period, independent on how long time is spent within a session. With the purpose to be able to compare our study with others we also reported these numbers for adherence, recommended number of sessions were 48 over 16 weeks. Outcomes for adherence was analysed with Mann-Whitney U-test. All data were analysed using IBM Corp. Released 2016. IBM SPSS Statistics for Macintosh, Version 24.0. Armonk, NY: IBM Corp.

Ethical considerations

The study was approved by The Regional Ethical Review Board in Umeå (Dnr 2016/106-31). All participants got written and verbal information about the study and gave written informed consent. Concerns about safety to prevent falls during exercising was considered, it was stressed both during the introduction as well as in the information given in both programmes. Exercise was preferably done close to a wall, sturdy furniture or surface for support, and adapted to the participants’ functional level. Material in the programmes was clear and tailored to the age group to ensure good understanding and reduce any possible risks.

Results

Participants

In total, 67 participants were enrolled in the study, 43% chose the DP and 57% chose the PB. Overall there were no major significant differences between groups at study start (Table
The mean age was 76 and 77 years respectively, the majority were women and only a minority were physically inactive (SGPALS level 1-2). Over 90% had experienced deterioration in balance during recent years and nearly 60% reported at least one fall the past year (fall range 1-6 falls). Few used walking aids: only two participants (both in the PB group) used a rollator for indoor use, for outdoor use it varied from Nordic walking poles to electric wheelchair. The most prevalent medical condition in both groups were heart- and cardiovascular diseases, and these were significantly less common in the DP group. The DP group also had a significant more positive attitude to the programme at start. Access to smartphone or tablet was significantly higher in the DP group.

A comparison of participants from the two different recruitment strategies showed significant differences for three background variables (data not reported). The health care centre group self-reported more lung conditions (p=.022) and being less physically active during summer months (p=.048) than participants recruited from the senior citizen organisations. For participants recruited from the senior citizen organisations access to a computer was significantly higher (p<.001).

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Digital programme n=29</th>
<th>Paper booklet n=38</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years, mean ±SD</td>
<td>76 ±5</td>
<td>77 ±3</td>
<td>0.508</td>
</tr>
<tr>
<td>Women, n (%)</td>
<td>18 (62)</td>
<td>30 (79)</td>
<td>0.173</td>
</tr>
<tr>
<td>Living alone, n (%)</td>
<td>13 (45)</td>
<td>17 (45)</td>
<td>0.994</td>
</tr>
<tr>
<td>Education, n (%)</td>
<td></td>
<td></td>
<td>0.117</td>
</tr>
<tr>
<td>Primary</td>
<td>11 (38)</td>
<td>23 (61)</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>9 (31)</td>
<td>10 (26)</td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td>9 (31)</td>
<td>5 (13)</td>
<td></td>
</tr>
<tr>
<td>Reduced balance last few years, n (%)</td>
<td>26 (90)</td>
<td>36 (95)</td>
<td>0.645*</td>
</tr>
<tr>
<td>Fall during previous 12 months</td>
<td>17 (59)</td>
<td>22 (58)</td>
<td>0.952</td>
</tr>
<tr>
<td>Indoors</td>
<td>6 (21)</td>
<td>4 (11)</td>
<td></td>
</tr>
<tr>
<td>Outdoors</td>
<td>9 (31)</td>
<td>14 (37)</td>
<td></td>
</tr>
</tbody>
</table>
Both indoors and outdoors 2 (7) 4 (11)
Able to take a 5 min brisk walk 25 (86) 34 (90) 0.719^f
Use of walking aids 4 (14) 10 (27)^f 0.192

Medical conditions, n (%)
Heart- and cardiovascular conditions 15 (52) 29 (76) 0.036
Neurological conditions 3 (10) 3 (8) 1.0^f
Musculoskeletal conditions 3 (10) 5 (13) 1.0^f
Endocrinological conditions 6 (21) 7 (18) 0.816
Lung diseases 3 (10) 6 (16) 0.721^f
Eye conditions 7 (24) 10 (26) 0.839
Osteoporosis 1 (3) 5 (13) 0.224^f
Dizziness 7 (24) 9 (24) 0.966
Cancer diagnosis\(^1\) 3 (10) 2 (5) 0.645^f
Other conditions\(^2\) 0 4 (11) 0.127^f

Access to smartphone/tablet, n (%) 23 (79) 16 (44)\(^2\) 0.004
Access to computer 26 (90) 27 (75)\(^2\) 0.130

Inactive (1-2) SGPALS\(^4\), n (%)
Summer 1 (3) 7 (18) 0.125^f
Winter 1 (3) 8 (21) 0.067^f

SPPB\(^4\), median (Q1-3) 9 (8-10) 10 (8-10) 0.402
ABC\(^5\), median (Q1-3) 85 (73-92) 83 (69-89) 0.393
AFRIS\(^6\), median (Q1-3) 38 (37-42) 37 (36-40) 0.035

\(^{1}\) Cancer types: Gastrointestinal stromal tumour, Breast ca, Malign melanoma, Chronic lymphocytic leukemia, Prostate ca.
\(^{2}\) Other: Kidney disease, Ulcerative colitis, Varicose veins, Electro hypersensitivity (EHS)
\(^{3}\) Saltin Grimby Physical Activity Level Scale, dichotomized into inactive=level 1-2 and active=level 3-6.
\(^{4}\) Short Physical Performance Battery, max 12 p.
\(^{5}\) The Activities-specific Balance Confidence Scale, 0-100%
\(^{6}\) Attitudes to Falls Related Interventions, 6-42 p.
\(^{†}\) 1 person missing
\(^{‡}\) 2 persons missing
\(^{f}\) P-value for Fisher’s exact test

**Attrition**

Five participants (17%) in the DP group and 14 (37%) in the PB group withdrew explicitly from the intervention, the difference was not statistically significant (p=.078) although clinically important. Figure 2 illustrates the flow of participants’ participation in the...
study. The withdrawals included one after just two days, six during the phone-interview a few weeks into the intervention, and the rest withdrew their participation before or around two months into the intervention. Around 70% of the withdrawals were reported to relate to factors not linked to the intervention programmes: own illness, illness within the family, or other engagements. Two participants stated that the exercises were too easy. One participant died during the period, by causes not related to study participation. Participants not completing the study showed no differences for background characteristics apart from a trend towards a lower education level, which might relate to the slightly higher education level in the DP group. The attrition rate was significant larger in the health care centre group with a 46% withdrawal rate compared to 17% recruited at senior citizen organisations (p=.010).

Adherence

Both intervention programmes had 24 participants completing the study. Among participants using the DP, 17 exercised at least 12 of the 16 weeks (exercise completion ≥75%) and 9 of these reported ≥75% or more of the recommended exercise duration. The corresponding numbers for the PB group were 19 and 13 participants respectively. The DP group and the PB group did not differ significantly in number of participants in these subgroups.

An illustration summarising weeks of self-reported exercise for both groups is shown in Figure 3. Of all enrolled participants, 50-59% reported exercise completion ≥75% weeks and a large proportion of PB participants did not report any exercise at all.

Among those that completed the study there were no significant difference in exercise duration between groups. However, for self-reported total minutes, 55% of the participants in the PB group reached ≥75% exercise duration compared to 37% in the DP group. Conversely, a greater proportion of participants in the DP group exercised more than the recommended duration (>100%) (Figure 4).
Reported median exercise time and number of sessions per week is presented in Table 2 with data separate for the four subgroups with respect to adherence. A significant difference between the programmes was only seen in the subgroup completing ≥75% of the recommended exercise duration, with 38 median minutes more per week in the DP group (p<.001). In Figure 5 the change over time can be seen for each programme, between two subgroups (Completed the study and Exercise duration ≥75%). The weekly variation appears larger for the DP group. Around week 12 of the intervention, the Christmas festive season occurred, for the majority of participants which may explain the dip on the graph.

Neither the median number of sessions per week nor adherence as percentage of the recommended number of sessions, did differ significantly between groups for any of the subgroups. Mean adherence of more than 100% reflects participants exercising more than recommended 3 times per week.

<p>| Table 2 |
|------------------|------------------|------------------|
|                  | Digital programme | Paper booklet    | p-value   |
| <strong>Enrolled</strong>     |                  |                  |           |
| n=29             |                  | n=38             |           |
| Total minutes per week | 61 (0-110)       | 65 (0-84)        | 0.450     |
| Sessions per week       | 2.3 (1.4-2.9)    | 2.0 (0.2-2.9)    | 0.447     |
| Mean adherence of 48 sessions | 63% | 54% | 0.183     |
| <strong>Completed study</strong> |                  |                  |           |
| n=24             |                  | n=24             |           |
| Total minutes per week | 65 (44-117)      | 75 (61-88)       | 0.703     |
| Sessions per week       | 2.5 (1.8-3.0)    | 2.7 (2.0-3.0)    | 0.570     |
| Mean adherence of 48 sessions | 74% | 80% | 0.893     |
| <strong>Exercise completion ≥75% of weeks</strong> | | | |
| n=17             |                  | n=19             |           |
| Total minutes per week | 86 (58-136)      | 81 (61-89)       | 0.375     |
| Sessions per week       | 2.7 (2.4-3.2)    | 2.8 (2.0-3.0)    | 0.557     |
| Mean adherence of 48 sessions | 91% | 91% | 0.505     |
| <strong>Exercise duration ≥75% of recommended minutes</strong> | | | |
| n=9              |                  | n=13             |           |
| Total minutes per week | 123 (110-156)    | 85 (75-94)       | 0.001     |
| Sessions per week       | 3.1 (2.9-3.8)    | 2.9 (2.6-3.1)    | 0.081     |</p>
<table>
<thead>
<tr>
<th>Mean adherence of 48 sessions</th>
<th>108%</th>
<th>103%</th>
<th>0.094</th>
</tr>
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<tbody>
<tr>
<td>Values are expressed as median (Q1-3) for minutes and sessions, and in % for mean adherence.</td>
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</table>

A comparison of background data for the subgroup that fulfilled ≥75% of exercise duration (n=22), revealed only that this subgroup was younger with a mean age of 75 (±3), compared to those not reaching ≥75% exercise duration, mean age 78 (±4) (p=.029).

Participants in the peer-mentor groups (n=9) reported similar exercise adherence, median 65 (45-95) minutes per week, as participants in the DP group without group meetings (n=15; median 63 (55-148) minutes per week; p=.571).

**Technical support**

Records of contacts from the DP group showed that support was needed in relation to: self-reporting of exercise n=6, log-in issues n=6, navigating the programme n=4, hardware issues n=3, Wi-Fi/data plan n=1. The actions to reported problems were: problem was sorted over the phone or by email n=9, an alert was directed to a person responsible for the server n=6, or a personal meeting took place n=3, the problem had resolved and did not need an action to be taken when re-establishing contact n=2. None of the issues were severe to resolve, often the problem occurred due to incorrect handling of the application, or that there was a current server error.

**Survey at four months**

The post-assessment questionnaire had a response rate of 93% for participants in the DP group and 71% for the PB group, none of the participants that had withdrawn answered the questionnaire. Table 3, part 1, gives responses for all eleven statements. Both groups were content with their programme, but the DP users reported a significantly higher degree of: being content with the programme and feeling supported by the programme, and also reported perceived improved leg-strength. One statement was boarder significant “difficult to choose exercises at right level” (p=.050).
Positive effects were reported more than negative effects (Table 3, part 2). The only significant difference between the programmes was that none in the DP group reported that they did not notice any positive effects, compared to 26% in the PB group.

In both groups, 89% would recommend the programme to others, and 82% in the DP group and 70% of PB users planned to continue with the programme after study completion, there were no significant differences between groups.

Adverse events

One person in the PB group reported two falls during exercise but suffered no injury. For the DP users no falls were reported during exercise.

Table 3

Results from the post-assessment questionnaire about experiences during the intervention.

**Part 1** Statements reflecting degree of agreement to the statement scored from 1-5, 1 = strongly disagree, 5 = strongly agree, values are presented as median (Q1-3); **Part 2** Present number of participants experiencing positive and/or negative subjective effects multiple answer possible, values are presented as n (%).

<table>
<thead>
<tr>
<th>Part 1</th>
<th>Digital program</th>
<th>Paper booklet</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeling content with the programme</td>
<td>5 (4-5)</td>
<td>4 (3-5)</td>
<td>.026</td>
</tr>
<tr>
<td>Programme was a support</td>
<td>5 (4-5)</td>
<td>4 (4.5)†</td>
<td>.044</td>
</tr>
<tr>
<td>Programme was difficult to use</td>
<td>1 (1-3)</td>
<td>1 (1-3)</td>
<td>.606</td>
</tr>
<tr>
<td>Programme contains challenging exercises</td>
<td>4 (3-4)</td>
<td>3.5 (3-5)†</td>
<td>.804</td>
</tr>
<tr>
<td>Difficult to choose exercises at right level</td>
<td>1 (1-4)</td>
<td>3 (2-4)†</td>
<td>.050</td>
</tr>
<tr>
<td>Worry about safety while practising</td>
<td>1 (1-2)†</td>
<td>1 (1-2)</td>
<td>.696</td>
</tr>
<tr>
<td>Practice the same time of the day</td>
<td>3 (2-4)</td>
<td>2.5 (2-3)†</td>
<td>.798</td>
</tr>
<tr>
<td>Difficult to find a place to do programme</td>
<td>1 (1-2)</td>
<td>1 (1-3)†</td>
<td>.169</td>
</tr>
<tr>
<td>Prefer to work out hard</td>
<td>3 (2-4)</td>
<td>3 (3-4)†</td>
<td>.648</td>
</tr>
<tr>
<td>Improved balance</td>
<td>4 (3-5)</td>
<td>4 (3-4)†</td>
<td>.109</td>
</tr>
<tr>
<td>Increased leg-strength</td>
<td>4 (3-5)</td>
<td>3 (3-4)†</td>
<td>.032</td>
</tr>
</tbody>
</table>

**Part 2**

Positive effects

<table>
<thead>
<tr>
<th></th>
<th>Digital program</th>
<th>Paper booklet</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>More energy/stamina</td>
<td>13 (48)</td>
<td>7 (26)</td>
<td>.091</td>
</tr>
</tbody>
</table>
Improved mood 3 (11) 7 (26) .161
Improved well-being 19 (70) 13 (48) .097
Other... 3 (11) 3 (11) .284
No, no positive effects 0 7 (26) .010
Negative effects
Pain 2 (7) 5 (19) .224
Dizziness 0 3 (11) .075
Stress 1 (4) 2 (7) .552
Tiredness / Fatigue 1 (4) 1 (4) 1.0
Other... 1 (4) 2 (7) .417
No, no negative effects 22 (82) 16 (59) .074

† 1 person missing
‡ 2 persons missing
P-value for Fisher’s exact test

Survey at 12 months
The response rate was 98% (24 DP, 20 PB) on the follow-up survey at 12 months after
the intervention started. Among DP users 67% exercised regularly, the whole programme or
parts of it and significantly more than PB users where the corresponding proportion was 35%
(p=.036). Among participants from both groups that didn’t continue with the programme or
just did it occasionally (n=21) 14% said they would take it up within the month, 43% maybe
would take it up again and 10% said that they would not take it up (both from the PB group),
and 33% did not answer. The most frequently reported reasons not to continue with the
programme was that they had started with other exercises or that they just didn’t do it. Lastly,
the 16 DP users that continued with the programme reported that they opened the programme:
weekly 19%, monthly 19%, at times 38%, or never 25% (learnt the programme by heart).

Discussion
This study showed that when participants selected their preferred programme, slightly
less participants choose to exercise with the DP, however the attrition rate was higher in the
PB group. Despite allocation by participant preference both groups were comparable, no
major differences for background characteristics were found. Adherence was generally
comparable between the groups, but among frequent users, participants in the DP group reported significantly more minutes of exercise per week in comparison to corresponding PB users. Overall, both groups reported being content with their programme, however DP users reported a higher degree of being content and feeling supported by the programme and they more likely agreed to feeling improved leg-strength. At the 12 months follow-up, 2/3 of participants using the DP continued to exercise regularly compared to 1/3 in the PB group.

**Adherence**

The adherence to the programmes was evaluated in the participants own environment as a self-managed exercise intervention. For home exercise programmes many different ways of describing adherence has previously been used. Some studies have reported adherence in minutes or weeks, but adherence in percentage of number of completed sessions is most commonly reported although in various modalities. In our study the completed percentage of recommended number of sessions was equivalent between groups. For all enrolled (subgroup 1); the DP group had 63% adherence, and PB group 54%; for those who completed the study (subgroup 2) the adherence was 74%; and 80% respectively. Adherence in terms of completion of the exercise programme, showed that within both groups half the participants or more reported exercise at least 12 of the 16 weeks (subgroup 3), and one third reached ≥75% of the recommended exercise time (subgroup 4).

Lack of uniformity for reporting adherence makes comparison between studies complex. Moreover, reports of adherence in other self-managed digital fall prevention exercise interventions, are still limited. In our study adherence was measured through self-reports. Several other digital interventions have used the connection time to the application to measure adherence. Considering these dissimilarities, The ActiveLifestyle study [18] indicated similar adherence as in our study: Users of the App with social features had 73% mean adherence of recommended exercise time, the App without social features had 68%, and the Paper programme (control) 54%. In a similar way Dekker et al. [29] reported 68% adherence in a 12
weeks ICT-supported self-management programme, offering an individually tailored fall prevention exercise programme. In comparison, an exergaming intervention iStoppFalls [30], reported 38% adherence as the proportion of participants reaching 1h exercise per week during their four months intervention.

The PB is based on the Otago Home Exercise Programme, which was originally a programme including regular follow-up, by home visits or telephone calls. In our study the exercise programme was completely self-managed after only one introduction session. Within falls services in the UK, an average of eight group sessions followed by home exercise with a booklet without follow up, is common practice [13]. The Otago Home Exercise Programme has, to our knowledge, not previously been evaluated as a completely self-managed programme but our study indicates that it was a feasible approach with similar adherence levels as for the DP. Studies evaluating the Otago Home Exercise Programme, where home visits were part of the intervention, has shown variable degree of adherence. In a one-year study Liu-Ambrose et al. [31] reported 25% adherence for the recommended exercise three times per week, and 68% for exercise at least once per week. Arkkukangas et al. showed adherence rates of 77% at 12 weeks follow-up [32], and after one year 46% [33]; for a minimum of two exercise sessions per week. In yet another study, the Otago Home Exercise Programme was complemented with DVD support for a six months intervention, where Davis et al. [12] presented 36% adherence, also for minimum two sessions per week.

In a review focused on how different interventions could improve adherence in fall prevention exercise interventions for older adults adherence rates between 27-97% was reported [34]. Variation in how adherence was measured limited the interpretation, and a valid objective measurement for both adherence and outcome was called for. Another review targeting exergaming for physical and cognitive effects in older adults, reported 79% mean adherence rate (range 49-96%), however only 1/3 of the studies provided home exercise [35].
Their conclusion was that future research need to evaluate home-based, self-managed interventions and called for robust RCT studies in this field [35]. Both review papers graded, the included studies, as of low evidence quality. Further, both papers address the need to evaluate adherence in a uniformed way, to be able to compare studies [34, 35].

**Attrition and attitude**

The attrition rate, the part of participants that withdraw from the study, could be affected by the attitude to an intervention, considering the motivation to realise exercise. Yardley et al. [26] describes the importance of being positive towards the programme to increase participation. The attitude to the programme was assessed with the AFRIS questionnaire at the start of our study and indicated that the participants in the DP group had a more positive attitude to the exercise programme. The significant lower AFRIS score in the PB group was probably a result of a bigger range in scores in this group, which maybe explain the lower attrition rate in this group. Further, the clinically relevant higher attrition rate in the PB group (p=.078), could be related to the two recruitment strategies, further discussed as a methodological consideration. Similar attrition rates as ours, of approximately 20%, has been reported in evaluations of other digital exercise interventions over 3-4 months [18, 29, 30]. For the ActiveLifestyle study the control group used a paper programme where attrition rate was 41%, slightly higher than ours [18].

**Exercise maintenance**

When following-up with a postal survey after 12 months, as much as 80% of DP and 75% PB participants reported exercising with the programme at times, or even more regularly. In comparison to other fall prevention studies Clemson et al. reported that 57% continued the integrated LiFE programme and 42% the standard programme at 12 months [6] and Iliffe et al. showed that between 40-50% of participants in the ActiveLifestyle study were achieving ≥150 min moderate-to-vigorous physical activity per week at 12-month follow-up [11].
The high rate of exercise maintenance after one year, reflected in our survey, may indicate that it was easy to continue doing the exercises when the programme got incorporated in regular activities. Our research group has previously published a qualitative study reporting on participants experiences of partaking in this feasibility study [36] and some of the aspects revealed might explain the high exercise maintenance. Participants from both groups expressed a capability and willingness to manage their exercise independently. The digital programme participants expressed views like: it was easy to choose exercises at an adequate level of difficulty, videos provided useful suggestions how to alter exercises, and videos reduced interpretation of how to perform the exercises. The digital program strengthened the feeling of support, which might create better opportunities for acceptance and adherence in the long term. The conclusion from this qualitative analysis was that the digital programme seems to have supported learning and reflection more than the paper booklet [36].

Methodological considerations

The reason for the participant preference trial was to evaluate the interest, and use, of a digital programme in a real-life context, and to consolidate the interest for both programmes in this exercise intervention. The patient preference trial is an appealing method to try to improve adherence in interventions [37]. Our study showed better adherence than other, randomised studies [12, 30, 31]. It was positive that even without randomisation the participants’ characteristics were comparable at study start for the two groups. Both groups self-reported relatively good health and would be considered a less frail population. In the PB group more participants indicated to be inactive even though not significantly, so in general we describe both groups as relatively active.

In this study no technical devises were provided to participants, so therefore the significant difference for access to smartphone in the DP group was expected. The intention of this project was to offer this new digital fall prevention programme to persons that have access to and are familiar with technology in order to self-manage this type of programme.
This feasibility study was a preparation for a now ongoing large RCT, were the possibility to provide devices will not be possible.

Two different recruitment strategies were used in this study, participants were recruited from a health care centre and through senior citizen organisations. The primary health care service has, in a systematic descriptive review, been considered a good recruitment strategy to identify people for fall preventive exercise interventions [38]. However, we found that fewer participants from the health care centre (primary care) chose the digital programme, which can have many possible reasons. Firstly, health care professionals imparted the information at the health care centre and they may had less time to explain the programmes, which might have affected the selection of programme. Secondly, a more detailed description of the new digital programme may be needed to make an informed choice. The preunderstanding of a paper booklet might have favoured the choice of this programme, as choosing the known might be an easier choice. Thirdly, access to a computer was significantly lower among the health care centre recruits, and may also reflect their previous experience of using technology who did not favour the DP. Furthermore, participants from the health care centre were less likely to finish the intervention which might explain parts of the higher attrition rate among PB users. Participants recruited at a health care centre might also have expected some other treatment, rather than self-management through a home exercise programme, which may influence their attitude towards the programme. These two different recruitment strategies could be further investigated, to be able to find an effective way to implement this type of fall preventive initiative.

To evaluate adherence, and compare the actual use of the two programmes, we created four subgroups according to participation in the intervention. Just over half of the participants completed more than 12 of the 16 weeks (75%) of the intervention (subgroup 3), and one third of the participants completed ≥75% duration for reported exercise time (subgroup 4). Different studies have used different cut-off points, we based our (75%), on the review by
Hawley-Hague et al. [28] and the ActiveLifestyle study Van het Reve et al. [19]. Using this cut-off point allows for some short illness during the study period, or lapses due to holidays or festive season. However, these recommendations for definitions of adherence were based on participation in exercise classes [28], consequently it could not be followed entirely in our study.

In our study adherence was based on data from exercise diaries, with self-reported time spent performing the exercises and what exercises that were performed. Maybe participants’ aspiration to accomplish the task exactly as recommended, lead to over or under estimation of self-reported time. A study exploring self-reported physical activity compared to accelerometer measured activity, showed an over estimation of the active time when self-reporting [39]. Further, comparing paper and electronic diaries in pain patients, showed a high frequency of bogus entries in both groups, while hording and/or filling in in advance was common for the paper diary as no time constraint existed to enter data. Also a poorer compliance was reported for the paper diary [40]. In our study, the digital exercise diary permitted data entry once per day, to report retrospectively but not in advance, and the paper diary had no limitations. The DP users predominantly reported either a lot more or less than recommended exercise time. Possible explanations for this peculiar u-shaped pattern was gained from participants during the final meeting where some explained that they regularly practiced without reporting it in the application. Others stopped using the application regularly while exercising, as they learned the programme by heart and did not open the application. In that sense a paper diary was easier to access, and such oversights could explain the low numbers of DP users in the span 75-100% of exercise duration. Additionally, the monthly reviews of the DP diaries were not realised in the penultimate month (as the data was not provided to the research assistant), causing a plausible risk that the adherence for the second part of the study in the DP group was affected. Other studies have used the actual connectivity of the app or exergame to monitor adherence [18, 29, 30], but the question rise if
an over reporting of adherence may occur, when e.g. every connection to show someone the
programme or go back and repeat watching a section, will be reported as exercise. There is a
need for more studies to evaluate adherence to new digital fall prevention interventions and
consistency in the way adherence is assessed.

Conclusion

The main goal of this feasibility study was to explore older adults’ participation in a four-
month self-managed fall prevention exercise intervention and specifically compare adherence
when using a digital exercise programme or a paper booklet. Among participants who
completed the study adherence was similar between the digital and paper programme.
However, the PB group had a clinically relevant higher attrition rate, and frequent users in the
DP group reported more exercise. A lesson learned was that collecting data on adherence is
complex and the different ways of self-reporting exercise may have affected the results. With
respect to the complexity of adherence, our study showed similar adherence as other
published studies of digital exercise fall prevention programmes and even higher than in other
studies of paper-based programmes. Overall, participants who completed the study were
satisfied with the chosen programme and at 12 months follow-up a greater proportion of
participants using the DP continued to exercise regularly. The results from this study shows
that both the digital programme and the paper programme have potential to be used as self-
managed fall prevention exercise interventions and the digital programme seems to facilitate
regular exercise after the intervention period. In a coming RCT study the digital programme
will be investigated without any in-person interaction.

List of abbreviations

DP = Digital exercise Programme

HC = Health care Centre
Declarations

Ethics approval and consent to participate

The project was approved by The Regional Ethical Review Board in Umeå (Dnr 2016/106–31). The participants were aware that their anonymised data would be used and all gave written informed consent prior to data collection.

Consent for publication

All participants gave written permission to use their anonymised data for publication purposes.

Availability of data and materials

The data used to support the findings of this study are available from the corresponding author on reasonable request.

Competing interests

DS is Director of Later Life Training, a non-profit making organisation who provide the Otago Home Exercise Booklet free online. All other authors declare that they have no competing interest. The application was developed collaboratively and it will not be sold for profit.
Funding

This work was financially supported by the Swedish Research Council (grant number 521–2011-3250 and grant number 2015–03481); the Strategic Research Programme in Care Sciences (SFO-V), Umeå University and Karolinska Institutet, Sweden; the Swedish Research Council for Health, Working Life and Welfare (FORTE); and King Gustav V and Queen Victoria’s Freemasons’ Foundation. The research was made possible using the funding but funders were not involved in the design of the study, data collection, analysis, interpretation, writing of the manuscript or decision to submit for publication.

Authors’ contributions

MS, LLO, DS conceptualized the study. MS and LLO collected funds for the study and were the persons introducing the programmes at the introduction meeting. LM, took part in data collection, and administration. LM analysed the data in collaboration with LLO, ER and MS. LM drafted the manuscript and LLO, ER, DS and MS were major contributors in writing the manuscript. RJ and HL revised the manuscript, and contributed in the design and development of the digital application, and technical support during the study. All authors read and approved the final manuscript.

Acknowledgements

We want to thank the participants who took part in this study and the two independent physiotherapists who did the blinded assessments. Also, Beatrice Pettersson, for her contributions in the planning stages of the study and in recruitment of participants.


32. Arkkukangas M, Söderlund A, Eriksson S, Johansson A-C. Fall preventive exercise with


**Figure Legends**

**Figure 1**

Overview of feasibility study. Key: HC= Health care Centre; SO=Senior citizen Organizations; DP=Digital exercise Programme; PB=Paper Booklet programme

**Figure 2**

Flow chart of participants’ participation in the study, the distribution of participants from the two recruitment strategies is also shown. Key: SO= Senior citizen Organisations and HC=

**Figure 3**
The proportion of enrolled participants for both programmes, reporting exercise completion by number of weeks with at least one self-reported exercise session. Divided in four categories: (a) none, (b) 1-5 weeks, (c) 6-11 weeks, and (d) 12-16 weeks with reported exercise.

Figure 4

Five categories of self-reported exercise duration (in percent of recommended 90 minutes per week), shown for those that completed the study (n=24 for each group).

Figure 5

Illustration of median time spent in minutes per week for two subgroups: Completed the study and Exercise duration ≥75%.
Example of the application’s interface (Safe Step v1 web-based or mobile application) with translation from Swedish. Please read Additional File 2 for more information about the content in the Safe Step application v1.

The home screen with four options:
- Go to the exercise programme (My Exercises)
- Access the exercise diary (Exercise Diary)
- Get hints about how to integrate exercises into everyday activities or outdoor (Integrate exercises into everyday activities)
- Get more information about the application (More about Safe Step)

The screen for My Exercises, with example of Sit to stand and Hip flexion exercises.
- To choose/change exercise click on the circle with a number (1-10 for the ten exercises) to show the list of selectable exercises.
- The video clip with exercise instructions starts and expands when clicking on the movie icon.
Supplementary Table 1. Template for Intervention Description and Replication (TIDieR) checklist

<table>
<thead>
<tr>
<th>Item no./Name</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1. Brief name | Safe Step  
A feasibility study of fall preventive exercise interventions delivered as a digital exercise programme or a paper booklet programme. The digital programme was Safe Step (v1), a web-based or mobile application and the paper booklet was a modified version of the Otago Exercise Programme. |
| 2. Why | A self-managed digital exercise program has been developed for community-living older people in order to potentially increase access to and reduce costs of fall-prevention exercise. Before evaluation in a larger randomized controlled trial this feasibility study was conducted to evaluate the digital programme in comparison to a paper based programme with respect to attrition, adherence, and self-reported experiences and effects. |
| 3. What: Materials | Both programmes provide a repository of evidence based exercises and were developed with inspiration from exercises in the Otago Exercise Programme (OEP), additionally the digital programme have exercises inspired from Falls Management Exercise Programme (FaME). Participants were instructed to build a complete programme of 10 different exercises. |

**Safe Step digital programme**
- Video clips with verbal instructions.
- A repository of exercises organized into 10 exercise groups: 5 to increase lower-limb muscle strength, 2 to improve balance, and 3 gait- and step exercises. Each group contained several exercises with varied levels of difficulty.
- Reasons for doing the exercise and how to adapt the exercise (for e.g. knee pain) were provided for each exercise group.
- Examples of exercises integrated into everyday activities and tips on how to do exercises outdoors.
- Behavior change support including: motivational feedback with written messages from virtual physiotherapist.

**Paper booklet programme**
- Drawings with written instructions.
- A repository of exercises organized into two sections of strength- and balance exercises. Each section was divided into three different levels of difficulty.
- The booklet had additional exercises for warm-up and stretching.
- Adaptation of exercises and reasons for doing the exercises were not provided.
- No integrated exercise practice was provided.
- No feedback or weekly planning tool was provided.
- The first page in the booklet presented general safety instructions for doing the exercise programme.
weekly activity planning, and monitoring progress (i.e. previous reported activities and frequency of exercise).

- Safety advice was provided in each exercise video and also for every exercise group. In addition, general safety information for everyday life was provided.
- Integrated self-reported digital exercise diary. Data saved on a secure server and reports monthly to the research group from an administrator.

- Self-reported paper-based exercise diary sent monthly to the research group.

4. What: Procedures

Participants self-selected their preferred intervention programme before study start. An introduction meeting included a short physical assessment, completion of questionnaires, and a short introduction of the exercise programme. At the end of the intervention a similar final meeting with post-assessments was held. A contact number to the project group was supplied if problems with the programme arose during the intervention.

5. Who provided

The intervention was self-managed and the participants chose the exercises and performed the programme independently over 4 months.

6. How

The individual programme was commenced after an introduction meeting. A short introduction of the programme was held in small groups of max 8 participants. The instructions were to build a programme with 10 different exercises from the repository. Participants were recommended to try the different exercises in each group, starting with the easiest and then choose one that was challenging but not too difficult. The digital programme was delivered via computer, mobile phone or tablet and the paper programme was delivered through a booklet.

<table>
<thead>
<tr>
<th>Safe Step digital programme</th>
<th>Paper booklet programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>- In video clips, the verbal instructions guided participants to start with 2 sets of 5 repetitions and continue to 10 reps before trying a more challenging exercise.</td>
<td>- Instruction page guided participants to start with 2 sets of 5 repetitions and continue to 10 reps.</td>
</tr>
</tbody>
</table>

7. Where

The participants decided themselves were to exercise, most probably in their own home or near environment. The introduction and final meetings were held at the recruiting health care centre or at the university campus.
8. When and how much  The recommendation was to exercise with the programme for 30 min, at least 3 times per week over 4 months, with instruction to progress the level of difficulty over the period according to their ability.

9. Tailoring  The participants were instructed to self-tailor the programme by choosing exercises that were challenging but not too difficult to perform, meaning exercising without losing balance or not being able to complete the number of repetitions. The individual programme could be progressed and tailored at any time throughout the 4-month intervention.

10. Modifications  N/A

11. How well: Planned  Adherence was self-reported by the participants in an exercise diary by recording exercises and time spent for each session and followed up monthly by the research team. In case of delay in exercise diary entry at the end of the month a phone call was made as a reminder.

11. How well: Actual  A drawback with participants individual exercise diaries was irregular data reporting from some participants during parts of the study. The attrition rate was 17% for Safe Step and 37% for paper booklet.