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A mixed-method exploration of the effects and feasibility of an intergenerational fall-prevention gardening programme in older adults at risk of falling: A clinical trial

Running headline: EFFECTS OF A FALL-PREVENTION GARDENING PROGRAMME

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Consent to participate: Informed consent was obtained from all individual participants included in the study.

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Abstract

Aim: Exercise-based fall-prevention programmes can significantly benefit older adults at risk of falling, yet drop-out and non-adherence are common. The current study investigated the feasibility and effects of an intergenerational, gardening-based fall-prevention programme. This intervention was chosen because gardening is known to have a multitude of positive effects and was considered as an attractive option for the target population.

Subject and Methods: Across three months, 16 individuals at risk of falling participated in eight weekly gardening sessions. Participants completed a battery of physical assessments and self-report questionnaires before and after the intervention. Focus groups were used to explore the participants' perceptions of the intervention.

Results: No statistically significant changes for the main physical and mental health outcomes were found, but participants reported increased confidence and reduced fear of falling. Qualitative analyses revealed that participants perceived the intervention to have diverse positive effects and provided important insights into participants' motivation for programme attendance.

Conclusion: A professionally designed and supervised gardening programme seems to be a promising fall-prevention intervention and adequately powered RCTs need to further examine the effectiveness of such programmes. Furthermore, the current findings have a high value for researchers and practitioners, as they highlight factors like purposefulness and cognitive stimulation which could be systematically targeted to further increase participants' motivation, acceptance, and adherence rates to fall-prevention programmes in general.

Trial registration number: ClinicalTrials.gov, *[number removed for review]*

Keywords: gardening, fall-prevention, qualitative methods, clinical trial

A mixed-method exploration of the effects and feasibility of an intergenerational fall-prevention gardening programme in older adults at risk of falling: A clinical trial

Falls and the fear of falling have been identified as a major health problem in the older population (Pereira et al. 2008; Montero-Odasso et al. 2021). While engagement in physical activity has been found to prevent falls, older adults who fell in the past and/or who experience a fear of falling often restrict their physical activities, especially when suffering from poor health (Pereira et al. 2008; Jenkin et al. 2017). This can lead to further functional decline, reduced mental health and social contact, and ultimately an earlier ageing institutionalisation (Pereira et al. 2008). Exercise-based fall-prevention classes have been found to effectively prevent falls, to increase physical activity levels, and to benefit multiple health outcomes (Gillespie et al. 2012; Montero-Odasso et al. 2021). Siegrist and colleagues (2016) for instance conducted a randomised controlled trial (RCT) with more than 370 participants, of whom 222 participated in an exercise group for 16 weeks. They found that the exercise programme led to significant reductions in the number of falls and fallers over a period of 12 months. Furthermore, only the exercise group showed reduced incidence rates of fall-related injuries and a reduced fear of falling, as well as improved physical functioning. Notwithstanding the effectiveness of such programmes, a high number of older adults at risk of falling are not willing to partake, as evidenced by acceptance rates of on average only 64% to exercise-based fall-prevention interventions in community settings (Nyman and Victor 2012). This lack of programme acceptance poses a big challenge in the field and warrants more fitting interventions, as well as a better examination of older adults' views about fall-prevention programmes (Bunn et al. 2008). The current study will pursue these goals by systematically examining the effects, feasibility, and participants' perceptions of an alternative, gardening-based fall-prevention program.

When examining the evidence on existing fall-prevention programmes, it becomes apparent that exercise-based fall-prevention programmes mostly consist of strength training and activities targeting balance, for instance walking, Tai Chi, or dancing (Bunn et al. 2008; Chen and Janke 2012). However, a review of facilitators and barriers to fall-prevention programme participation found that older adults who had not exercised at a younger age were less likely to participate in these typical exercise programmes. This was partly explained by the absence of exercise habits, the expectations of discomfort, and the perception of a misfit with one's personality or abilities (Bunn et al. 2008). Kirchhoff and Damgaard (2016), who investigated the uptake of and adherence to fall-prevention programmes in general, found furthermore that programme offers or referrals were often refused because potential participants were not interested or reported to not have enough energy. In line with these findings, the healthcare practitioners involved in the research project described in the current article heard from clients that they had no interest in standard exercise classes, like Nordic walking. Instead, several clients expressed a wish for more meaningful alternative exercise forms, an observation Åhlund and colleagues (2020) also reported for frail older adults with a severe comorbidity burden. Regarding potential facilitators for programme uptake, Bunn and colleagues (2008) furthermore found that the experience of social support and interaction, low to moderate intensity activities, and exercises tailored to the individuals improved adherence.

A type of exercise which connects to these facilitators and which at the same time mitigates all of the above-mentioned barriers to exercise-based fall-prevention programmes is gardening. Firstly, gardening is one of the most popular physical activities persons engage in during their leisure time (Ham et al. 2009). It is thus likely that older adults have engaged in gardening at some point of their life. For clients who have no earlier exercise history, gardening consequently represents a familiar activity pattern, and they might be more likely to participate in a gardening-based fall-prevention programme (Chen and Janke 2012). Secondly, gardening is

generally perceived as an enjoyable, purposeful, and meaningful activity (Patil et al. 2019; Åhlund et al. 2020). Thirdly, the tasks gardeners typically engage in, such as potting plants, watering, or harvesting, can provide specific physical health benefits by targeting balance. They also encompass different low to moderate intensity movements (Chen and Janke 2012; Park et al. 2015). Furthermore, when done in a group, these activities require cooperation and provide opportunities to support each other, share experiences, and connect to others (Wang et al. 2015). An inclusion of different generations in gardening programmes can even facilitate the connection between different generations and provide older adults with opportunities to convey knowledge (Brown et al. 2020; Jakubec et al. 2021). Thus, a group gardening programme could offer opportunities to promote social support and interaction, while gardening is well suited to tailor exercises to individuals – factors which have all been found to increase the acceptability of an exercise-based fall-prevention programme (Bunn et al. 2008; Chen and Janke 2012).

In addition to the unique appeal of gardening to the population of older adults, it has been shown that gardening in general has a multitude of positive effects on wellbeing and health (Van Den Berg and Custers 2011; Hawkins et al. 2013; Wood et al. 2016). These benefits include improvements in life satisfaction, positive affect, and quality of life along with a reduction in factors such as stress, anger, depression, and anxiety (Gigliotti et al. 2004; Wakefield et al. 2007; Wilson and Christensen 2012). Specifically within the older adult population, gardening has also been shown to promote higher levels of self-efficacy, self-esteem, and feelings of mastery, accomplishment, and competence (Wang and MacMillan 2013; Thompson 2018). Additionally, sole exposure to green environments, contact with nature, and physical activity outdoors have on their own also been found to be restorative and to increase health and wellbeing levels (Barton et al. 2016; Patil et al. 2019).

Considering the evidence reviewed above, it is no surprise that health professionals recommend to include gardening as a treatment option for clients whenever possible, as is already common practice in occupational therapy (Barton et al. 2016; Patil et al. 2019). However, this recommendation has not yet been adopted in the field of fall-prevention, even though Chen and Janke (2012) already hypothesised that gardening interventions could be very suitable to prevent falls. The authors based this conclusion on the findings of a large-scale (N = 3,200) cross-sectional study, showing that older individuals engaging in at least one hour of gardening per week had a better health status, better balance, and faster gait speed. They had furthermore fallen less often in the previous two years than individuals who did not engage in gardening that much. Even though the authors did not find gardening to be a significant predictor of falls when controlling for health and fall risk factors, they suggest that gardening can influence the fall risk through its effect on factors such as health status, balance, and gait speed. Chen and Janke (2012) therefore call for a carefully planned integration of gardening into fall-prevention interventions, ideally as a professionally monitored group-based gardening program, as group-based programmes appear to be more effective in general. Yet, despite the diverse support for gardening as an exercise-based fall-prevention programme, up to today there have been no systematic assessments of such interventions.

The current study therefore set out to for the first time systematically investigate the effects and the feasibility of a gardening-based fall-prevention programme. More specifically, it examined the hypotheses that regular participation in a group-based, intergenerational gardening programme would lead to improved physical and mental health outcomes, a reduced fear of falling, and enhanced physical activity levels, self-efficacy, and social connectedness in older adults at risk of falling. We additionally explored other beneficial effects, and the feasibility and sustainability of the programme, by examining falls and incidents and by investigating the subjective experiences of participants. The aim of the study was also to share useful empirical and practical

information to inform professionals in the field who are considering implementing a similar gardening programme. It should reveal whether gardening might offer a suitable alternative to standard exercise classes.

Methods

Study design

The study was a single-arm clinical trial and thus encompassed one gardening intervention group. It was not possible to include a control group as this would have affected the existing clinical care that participants were receiving. Due to limited resources, it was also not possible to implement a wait list control group as there was only funding to run the gardening programme once. The study was registered as a clinical trial (ClinicalTrials.gov identifier: *[number removed for review]*) and received approval by the Health Research Authority (HRA, National Health Service England) and the HRA Research Ethics Committee. Gardening groups were offered twice per week for three months, and each participant attended a total of eight gardening sessions, one per week, across this time period. The study aimed to explore the potential effects and feasibility of a new and innovative gardening intervention, although it was not planned to function as a feasibility study for a larger randomised controlled trial.

Participants

Participants were recruited from a pool of older adults who had completed a Falls and Bone Health Assessment with a specific *[number removed for review]* borough's Integrated Falls and Bone Health Service (IFBHS). In the following, these older adults will be referred to as clients. Only clients who had declined to take part in the usual prevention exercise programmes, and clients who had either completed or who were awaiting usual prevention classes were offered to participate in the project. This was done so as to not affect any existing, standard clinical care that participants were receiving. Clients furthermore needed to be able to mobilise without walking aids since the use of ambulatory assistive devices was not possible on the gardening site. Further exclusion criteria were having a known diagnosis of dementia, not being able to adequately understand verbal explanations or written information given in English, and having a high falls risk profile in a gardening context, as assessed by a clinical decision based on mobility and general health made by professionals of the IFBHS.

Recruitment took place via several staff members of the IFBHS who, as part of their normal care, informed eligible clients about the gardening programme and the associated study. We originally aimed to recruit 30 participants since a priori power analyses indicated that a total sample size of $N = 27$ participants would be needed for a paired t-test to detect an assumed medium sized effect (Soga et al. 2017) with a power of .80 and an alpha error probability of 0.05. However, the original target number of 30 participants had to be abandoned, as it became apparent during the first weeks of the project that it was not feasible to offer more than two gardening groups per week, and that no more than eight clients could participate per session to ensure health and safety. We originally planned to run three groups with ten clients per group. However, it soon became apparent that the amount of work in a garden, which needs time to grow, is limited. Although some extra tasks were added, such as building bird scarers, participants preferred to work with the plants and soil. Furthermore, the size of the garden made it difficult for more than eight participants to safely move around the site while receiving sufficient supervision from healthcare professionals and individual support from students and staff members. Apart from that, more staff members/volunteering students were needed than originally anticipated. The most comfortable clients to staff/volunteer ratio turned out to be between 2:1 and 1:1, depending on the participants' needs. Thus overall, 16 eligible clients were finally recruited (56% males; mean age = 77 years, age range = 59–89, of whom 75% had engaged in gardening activities before; one participant attended a standard

exercise-based fall-prevention class during the first week of the intervention). All participants took part voluntarily, provided written informed consent, and were advised of their right to discontinue the study at any time as well as to withdraw their consent afterwards. All 16 participants who started the programme completed it. However, due to the decentralised recruitment approach, we are unable to provide reliable information regarding the number of clients who were originally screened and/or assessed for eligibility (see Figure 1).

Intervention

From June to August 2017, two gardening groups with up to eight clients and about four to six supporting students/staff members per group were offered weekly. Participants were asked to attend the one-hour long gardening sessions for a total of eight times within a time span of three months to allow for sickness/personal reasons for non-attendance, and cancellations due to bad weather conditions. The gardening intervention took place at a gardening site on the campus of the University of [*University name removed for the review process*]. Guidance on the prevention of falls in older people by the National Institute for Health and Care Excellence suggests that fall-prevention programmes should be flexible enough to accommodate different needs and preferences, and that programmes should also have a social value (NICE 2013). As the University of [*University name removed for the review process*]'s campus is located in an area with a high density of social housing, we anticipated that an intergenerational gardening project, where older people from the community come together with student volunteers, would attract and benefit a diverse group of participants, including people whose fall risks are related to social isolation, the built environment, and other social and mental health risk factors.

The gardening site was purpose-built for the study, including the installation of two ground-level and six 2x1m raised beds to allow for gardening activities at comfortable working heights and to meet different physical needs (see Figure 2 and Supplementary Figure 1). All groups were led by an IFBHS exercise facilitator and an occupational therapist and were supported by university staff and student volunteers. Each intervention session was designed to accommodate relevant activities for the then-current point in the growing season and the development of the gardening site (i.e. what had grown, what could be sown or harvested, what needed further development/building); each session also accommodated the needs and status of the attending participants concerning their overall health state, their acute health state, and possible preferences for certain gardening activities. All gardening tasks were individually tailored to the participants by planning, adapting, and grading each task to ensure the core principles of strength, power, balance, and coordination were challenged to an appropriate level. A summary of the sessions and main gardening tasks used throughout the weeks, as well as the criteria for the newly built gardening site can be found in the online supplementary material.

Measurements

Immediately before starting the first gardening session and on the day of the last gardening session, all participants completed a pre-intervention (T1) and a post-intervention (T2) assessment which lasted 15-20 minutes. In this assessment, participants completed several questionnaires and functional mobility tests related to their fall risk factors in order to assess the primary and secondary outcome measures. Furthermore, subjective experiences participants made in the gardening programme were explored by means of brief individual questions and two focus groups after completion of the programme.

Primary outcome measures

Physical mobility tests

Physical risk factors of falling were assessed by means of three different mobility tests which ran in the following order: a) Timed Up and Go Test (Podsiadlo and Richardson 1991): time in seconds needed to stand up

from a standard armchair, walk to a line that is 3 meters away, turn around at the line, walk back to the chair, and sit down; b) Timed 180° Turn Test (Robinson and Ng 2018): Number of steps required to turn in a half circle (180°); c) 30-second Sit-to-Stand Test (Jones et al. 1999): Number of complete chair stands (up and down equals one stand) completed in 30 seconds.

Health and wellbeing

Health was assessed via the EQ-5D-5L questionnaire (Herdman et al. 2011) which measures five dimensions of health, namely mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. For each health dimension, participants could choose from five response categories corresponding to "no problems", "slight problems", "moderate problems", "severe problems" and "extreme problems/inability". A response category for mobility was for instance: "I have no problems in walking about". Respondents were asked to choose the response that best described their health on the day of the measurement. The weighted index value, or EQ-5D health score, for the five dimensions was calculated for each participant, with higher values representing a better health status; the theoretical score ranged between worst health = -0.29 and best possible health = 1. Furthermore, the probability of improvements due to the intervention was examined for each dimension by means of the so-called Probability of Superiority measure (computed as follows: [# participants with positive change+0.5*# participants with no change]/# participants). Values above 0.5 indicated better health levels while values below 0.5 reflected worse health levels after the intervention compared to before the intervention (Devlin et al. 2020). The internal consistency of the scale was satisfactory at T1 and T2, with a Cronbach's alpha of .73 and .76 respectively (Seng et al. 2020).

Wellbeing was measured by means of the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (Tennant et al., 2007). The scale consists of 14 items which cover hedonic and eudaimonic aspects of mental health. Respondents rated their experience over the last two weeks on a 5-point-scale ranging from "none of the time" to "all of the time". An example item is "I've been feeling relaxed". We computed the mean value for each participant, with higher mean values indicating better levels of wellbeing. The internal consistency was very good at both T1 and T2, with a Cronbach's alpha of .94 and .96 respectively.

Fall efficacy

Perceived self-efficacy at avoiding a fall was assessed via the 16-item Falls Efficacy Scale-International (FES-I) (Yardley et al. 2005). Respondents rated their concerns about the possibility of falling in different situations, such as when "preparing simple meals", on a 4-point-scale ranging from "not at all concerned" to "very concerned". Sum scores were calculated, with higher scores reflecting higher levels of concerns about the possibility to fall. The internal consistency was very good at both T1 and T2, with a Cronbach's alpha of .91 and .93 respectively.

Secondary outcome measures

Falls and incidents

Participants indicated at T1 whether any falls had occurred in the last eight weeks in order to obtain a falls baseline measure. At T2, participants reported the number and location of falls which had occurred in the weeks since they had started the gardening intervention. To judge the programme's feasibility and risks, the number of falls or other incidents, such as near misses, during participation in the actual gardening sessions were also systematically recorded.

Activity levels

Changes in activity levels were assessed descriptively by asking participants the following question at T2: "Have you noticed any changes in your activity levels since the gardening programme has started?". The answers were coded as -1 (activity levels decreased), 0 (no change), 1 (activity levels increased), and 2 (no change, but positive physical and/or psychological changes).

General self-efficacy

General self-efficacy was measured by means of the Generalized Self-Efficacy Scale (Schwarzer and Jerusalem 1995). The scale consists of 10 items with a 4-point answer scale ("1 = not at all true" to "4 = very true"). An example item is: "I can always manage to solve difficult problems if I try hard enough". Higher values represent higher general self-efficacy levels. The scale's internal consistency was good and very good at T1 and T2, with a Cronbach's alpha of .84 and .93 respectively.

Social connectedness

Social connectedness was measured by means of the Social Connectedness Scale (Lee and Robbins 1995). The scale consists of eight items with a 6-point answer scale ("1 = strongly agree" to "6 = strongly disagree"). An example item is: "I feel disconnected from the world around me". Higher values represent higher social connectedness levels. The scale's internal consistency was good and very good at T1 and T2, with a Cronbach's alpha of .96 and .86 respectively.

Exploratory outcome measures

The survey also included two single items about *Confidence in achieving goals* and *Current fear of falling* as these are part of the standard IFBHS questionnaire. Respondents gave an answer to the question "How confident are you to achieve goals (on a scale from 0 to 10)?", and were asked to rate the extent of their fear of falling on an 11-point scale (from "0 = no fear" to "10 = terrified" (Denkinger et al., 2009). As these items were not officially preregistered, they are treated as exploratory outcome measures.

Participants' subjective experiences of the programme

At the end of the gardening programme, participants' subjective experiences of the gardening programme were assessed. First, participants shared their experiences individually in the T2 survey by answering four questions: a) how much he/she had enjoyed participating in the gardening programme, and how much he/she would like to continue attending a gardening group at *[name deleted for review]* campus (each question rated on a scale from "0 = not at all" to "10 = very much"); b) how he/she would summarise their experience in the gardening programme in one or two sentences, and what he/she had liked most and had not liked about the gardening programme. The answers to the open answer questions were summarised and written down by the investigator who completed the questionnaire with the participant; all answers can be found in Supplementary Tables 2 and 3. As a second assessment, two semi-structured focus groups were conducted. Participants were asked to discuss what they had liked/disliked about gardening and the gardening project (also in comparison to the standard exercise classes), whether they had experienced any changes in themselves during the programme, and what their opinions about possible barriers to continued engagement in such a programme were.

Data analyses

Due to the small sample size, all quantitative variables were checked for normality using the Shapiro-Wilk test. Changes in variables which were identified as being non-normally distributed, namely the Timed 180° Turn Test, EQ-5D health score, FES-I fall efficacy, goal achievement confidence, and social connectedness, were analysed by means of the Wilcoxon signed rank test for exact significance for related samples. Median instead of mean scores were reported for these variables. T-tests for paired samples were used to analyse changes

in normally distributed variables, namely the Timed Up and Go Test, 30-second Sit-to-Stand Test, wellbeing score, fear of falling, and general self-efficacy. For null hypothesis testing, the level of significance was set at $p < .05$. All data were analysed using SPSS Statistics 27.

The focus groups were transcribed verbatim (omitting utterances like uhm and ahs). Grammatical mistakes or redundant words were not corrected to allow the reader to better empathise with the speakers. The focus group transcription as well as the summary to the open answers in the questionnaire were analysed using a theoretical thematic analysis at the semantic level. We used a realist thematic analysis approach, as the goal of the analysis was to reflect participants' motivations, experience, and meaning by describing, summarising, and interpreting patterns in semantic content (Braun and Clarke 2006). Coding was done using the programme ATLAS.ti.

Results

The results (mean [*M*] or median [*Md*], standard deviation [*SD*], *p*-value, effect size) for all quantitative primary and secondary outcome measures are depicted in Table 1. On a descriptive level, all changes observed from T1 to T2 reflect improvements.

Primary outcome measures

Statistically significant changes from T1 to T2 were not found for any of the three physical outcome measures *Timed Up and Go Test*, *Timed 180° Turn Test*, *30-seconds Sit-to-Stand Test*), nor for *Health*, *Wellbeing*, or *Fall efficacy* levels (all $p > 0.05$; see Table 1). Even though not statistically significant when testing the null hypothesis, medium to large effect sizes emerged for the Timed 180° Turn Test and for changes in well-being. For health, the probabilities of superiority for each of the five EQ-5D dimensions were: mobility = 0.56; self-care = 0.53; usual activities = 0.56; pain/discomfort = 0.66; anxiety/depression = 0.47.

Secondary outcome measures

No statistically significant changes from T1 to T2 were found for the main quantitative secondary outcome measures *general self-efficacy* and *social connectedness* ($p > 0.05$; see Table 1). The number of *falls and incidents* showed that no additional risk seemed to be related to participation in the gardening programme. In total, one subject reported one fall for the eight weeks before the start of the intervention and another person reported one fall for the time that the gardening intervention lasted, the latter fall not being related to the gardening sessions. During the gardening intervention, no falls and one near miss occurred when a participant lost his balance while digging and was supported by a support staff member to regain his balance.

The descriptive analysis of reported *activity levels* showed an increase for *s*even of the 16 participants. Five participants reported other positive changes related to engaging in physical activity, such as being more focused when walking, which meant being more confident. Three participants did not report any changes in their activity levels. One participant reported that his/her activity levels reduced, but clearly attributed this to a fall which occurred in the weeks during which he/she participated in the gardening intervention (see Supplementary Table 1 for all responses).

Exploratory analyses

Considering the descriptions of positive changes which were noticeable in the data, we questioned whether the scales we had chosen for the assessment of the interventions might not have been sensitive enough to detect change considering the low power our study had (Ching Ting Fok and Henry 2015). In line with Preston's and Colman's (2000) findings, we assumed that the 11-point scales which were included in the standard IFBHS questionnaire could provide participants with a better opportunity to express changes and thus

also analysed pre-post changes for both scales. For the extent of the *current fear of falling*, a statistically significant decrease was observed ($t(15) = 2.44$, $p = .028$, $d_z = 0.61$). After completion of the intervention, participants reported to be less fearful of falling ($M = 3.38$) than before the intervention ($M = 4$). The resulting effect size of $d_z = 0.61$ reflected a medium to large effect. The *confidence to achieve goals* increased significantly ($Z = -2.604$, $p = .003$, $r = -0.53$). After the intervention, participants were more confident in achieving goals ($Mdn = 9$) than before the intervention ($Mdn = 7.5$). The size of this effect was moderate.

Participants' experiences

Participants thoroughly enjoyed participating in the programme. This was reflected in the answers they gave in the survey (see Supplementary Table 2) and in the two focus groups (one with six and one with seven participants), as well as in their enjoyment ratings of the programme ($M = 9.22$, $SD = 0.88$ on a 0–10 scale). In line with these positive experiences, almost all participants indicated that they would strongly like to continue attending the gardening group ($M = 9.25$, $SD = 1.40$). When asked what they did not like about the programme, no generally negative points emerged. One individual did not really like the kneeling, another would have liked to see more physical change. The criticism which was mentioned most often was that the group should have lasted longer than just one hour (see Supplementary Table 2).

Apart from the outcomes assessed by means of physical tests, questionnaires and interviews, participants also voted with their feet: The study had a retention rate of 100%. All sixteen participants adhered to the gardening programme with no drop-outs, and everyone that completed the requested eight weeks of the programme before the official end date wanted to attend the gardening sessions beyond that point until the project had ended. Participants came in warm as well as in rather cold weather, and were not even put off by forecasted showers.

Thematic analysis

In addition to giving insights into what participants liked and disliked about the programme, the results of the thematic analysis describe what participants experienced throughout the programme. Three main themes were identified in the analysis of the focus groups and the open answer questions. First, the *motivating facets of the gardening programme*, second, the *special needs of the target group* which needed to be considered, and third, the *positive effects of participation* in the programme which emerged (see Figure 3). For each theme, several subthemes were identified, which will be briefly described below. The order of subthemes in which they are discussed does not reflect any differences in their importance. A more detailed table with several quotes for each subtheme can be found in the Supplementary Tables 4a, 4b, and 4c.

Motivating facets of the gardening programme

This theme describes the aspects which motivated participants to engage in the gardening sessions. The first of its five subthemes is *Positive group interaction*. This subtheme reflects that participants reported that the possibility to meet (like-minded) people regularly was very much appreciated by them. It allowed them to communicate with others and learn with and from others, and they liked being part of a team working together towards a goal. As participant 1 from the Wednesday group put it: "It's nice on Wednesdays I know when I come here, to be with very nice people" (Participant Wednesday #1; PW1).

The second subtheme was *Feeling of achievement*. Participants described that mastering the sometimes challenging gardening activities gave them a feeling of achievement, especially considering potentially limiting disabilities. This feeling of achievement was also supported by the fact that they were able to see what they had done throughout the weeks, and that they had also received products of their hard work: "Knowing you can do

something and it might just be, if I wanted to perhaps just grow a little bag of tomatoes. Even if it's just that, from here on in it's something. And you can watch it grow. And you got the end result as everybody said. It's a sense of achievement, isn't it?" (Participant Tuesday #6; PT6).

Body and mind was the third subtheme. Many participants reported they liked that the gardening sessions stimulated them mentally as well as physically. On the one hand, it allowed them to learn something new as participants were in touch with younger people, and because they acquired new knowledge about right movements, as well as about gardening, for instance regarding plants, tricks for older gardeners, and bed setups. On the other hand, most participants increased their activity levels, partly also because they had to walk to the gardening site. As participant W6 stated: "And also, many older people don't get to see younger people. I do think the generational thing can be physically but also emotionally and mentally stimulating for both. […] I can't stress enough, the emotional and mental benefits of it [gardening]. Of keeping the mind, you know, you learn more skills – physical skills – and you learn more knowledge, and the two of them are still, you know, helping the brain. Hopefully keeping Alzheimer's at bay". While gardening was by some described as less intense than standard exercise classes, it was also perceived as requiring more full bodily engagement.

The fourth subtheme was *Aesthetic and natural experiences*. Participants enjoyed to use different senses, for example, when seeing the colour of plants, tasting products, touching the soil, and being outdoors. They also liked to plant seeds and see how plants grow – an experience which cannot be achieved in standard exercise classes, as the following quote shows: "Exercise has for me a more rigid structure and no doubt based on the trainer's experience and your ability and the duration which you are going to do this. That's a different motivation. It's not as aesthetically pleasant as strolling around in the garden and poking at the soil. Eating tomatoes, checking out the colour, it's a different human experience – they're very different" (PT3).

The final subtheme which we identified was *Enjoyment*. Gardening was perceived as very pleasurable, for some more so than standard exercise classes, while for others it was comparable. Many of the above described aspects of gardening led the participants to enjoy themselves, especially the positive interaction in the group and the opportunities to learn. It was also experienced positively that the exercise felt more natural: "You're enjoying moving around more. It doesn't seem like an exercise because you're enjoying yourself" (PT7).

Special needs of the target group

This theme summarised how the participants felt that their special needs were taken into account in order to enable them to complete the programme. The first subtheme on which the other two subthemes seem to base was *Awareness of individual strengths and limitations*. Participants highlighted several times that it was important that staff members involved in the programme were aware of their personal health issues, their different (dis-)abilities, and their individual needs, such as those regarding safety measures or support: "People, they were very helpful, and they were watching you. Because some people are less able. Cause, I've got one leg that isn't quite, that is very weak. And they were very aware and, yeah. It was very good" (PT2).

The second subtheme *Thoughtful preparation of the site and sessions* builds onto this need for individual attention. It reflects the statements participants made regarding the importance of a gardening programme which was tailored to their needs. This relates both to the actual growing site and equipment, such as having raised beds, kneelers, and a bench in the shade, as well as to the activities done in each gardening session, which had to suit the season, the state of the plants, as well as individual needs and goals. This preparation, which was only possible due to the combination of physiotherapy and gardening knowledge in the person of ST, enabled participants to (re-)discover gardening activities: "I think, which I found is that it's well organised they tell you

what tasks are on today and let you work at your pace, no pressures, no, you know, you do things you want to do – in your own pace. And there are things that I say that I don't want to do today. And they say that's fine – choose something else. And also they give you suggestions: Why don't you do this? Yes, or no sorry, pick something else. So thank you for that because that encourages and helps us continue" (PW5).

Providing a safe space to 'grow' as the third subtheme relates to the previous subtheme, but it focusses more on psychological aspects relating to safety rather than the practicalities concerned with easy and safe gardening. Several participants highlighted how much it meant to them that they knew that fall-prevention professionals were watching them and instructing them how they could garden safely: "They provide the safeguards to make sure that nothing happens to us really" (PT6). Furthermore, the fact that there were often almost as many support staff members as there were participants meant that support was always available. These points seemed to help the participants, who otherwise reported that low confidence levels limited them in their activities, to engage in activities notwithstanding their fear of falling.

Positive effects of participation

Participants reported that they experienced various positive effects due to engaging in the gardening programme, which we summarised in three subthemes. Firstly, various *Improvements of mental and physical wellbeing* were highlighted. Participants for instance reported to feel healthier, satisfied, less fearful of falling, more confident, more purposeful, and more relaxed. For example: "Physically, it [gardening] helps you to mobilise and it helps you to be active and you know improve the wellbeing. I think that's a very, very important aspect" (PW5). "I used to have a fear of losing a sense of balance that has improved a lot. You could do it from various exercise, but this kind of project seems to have much improved the fear of falling. That has contributed a lot" (PW4).

Another subtheme was to *Having a goal and reason to go out*. This non-gardening specific aspect was reflected in various statements regarding the importance of engaging in a regular activity which gives one's day structure and a purpose: "And having to come out. A goal. Having to come out to meet people" (PT2). Just the fact that participants needed and wanted to go somewhere lead to an increase of their activity levels, as this quote shows: "Oh, it [participating in the programme] has given me discipline to, you know, focus on the day that I do it. Usually when I get back I want to carry on doing some gardening in my own garden. So it keeps it going. But, you know you're going to meet people who are doing the same thing as you, like minded and all that. You have to get up and keep to a timetable, which is not a bad thing and gives one a bit of focus" (PW6).

Exercise becomes more meaningful was identified as the last subtheme. Participants reported that by partaking in the gardening programme they started to appreciate other exercises they had learned in standard fall-prevention exercise classes more. They saw these exercises as a building block for gardening. By actually using certain gardening movements, they understood why it was important to practise it (see quote below). Some participants also said they realised that it is good to have a small warming up routine before engaging in physical activities, as was done before each gardening session.

> Participant W3: I think exercise, if you look back on the exercise, it ties in with the gardening. All the things that we did in the exercise, you suddenly realise, ah yes that's why we did that. Especially… [does a certain exercise movement].
>
> All: Oh yes [laughter].
>
> Participant W3: Coming to the gardening you need it.

Discussion

The current study investigated the effectiveness and feasibility of a group-based, intergenerational fall-prevention gardening programme. This was done by gathering and analysing quantitative as well as qualitative data. Statistical examination of the quantitative data showed no significant changes from T1 to T2 for the primary (physical mobility, health, wellbeing, and fall efficacy levels) or secondary (general self-efficacy and social connectedness) outcome measures. However, the current fear of falling and the confidence to achieve goals showed significant moderate to large improvements after the intervention in the exploratory analyses. The descriptive analysis of health, with the exception of the anxiety/depression dimension, and activity levels indicated that more participants experienced positive changes than negative or no changes. Furthermore, the qualitative analysis of participants' subjective experiences highlighted that they gained a variety of benefits related to the gardening programme and that is was a successful programme for them.

Effects of the programme

When solely considering the null hypothesis testing results of the study, there is only little support for the ability of the programme to improve physical and psychosocial health measures, since no statistical differences were found for any of the quantitative primary and secondary outcome variables. Only the exploratory analyses revealed significant reductions in the participants' fear of falling, and a significant increase in their confidence to achieve goals. These findings can partly be explained by the small number of participants the programme was able to accommodate due to practical and health and safety reasons. This means the study was underpowered. Differences from T1 to T2 might have not been statistically significant, even though variations were present, as indicated by medium effect sizes for many outcome variables (Visentin et al. 2020). This assumption is also supported when looking at the findings by Siegrist and colleagues (2016) who conducted a larger RCT with about 200 participants in their exercise group. They found similar – and in their case significant – improvements (0.9 seconds) for the Timed Up and Go Test, as did we (0.8 seconds). However, in contrast to our results, participants of this larger RCT also reported a significantly lower fear of falling after the intervention using the FES-I, with a change from 25.2 to 23.4 points. Noteworthily, their participants' fear levels were lower than the levels of our participants by an average of 29.5 points.

In line with Lambdin's (2012) warning about drawing premature conclusions based only on significance testing and the practical significance of results (Lakens 2013), we do thus not conclude that the gardening intervention had no effects. We also come to this conclusion because of the qualitative findings of this study, since one of the themes identified in the thematic analysis describes the positive effects participants experienced due to their participation in the programme. In line with the effects known to be linked to engagement in gardening activities (Van Den Berg and Custers 2011; Wood et al. 2016), participants reported a multitude of positive states and feelings, and various improvements in mental and physical wellbeing and health outcomes. A majority of the participants furthermore reported that their participation in the gardening intervention either increased their activity levels or influenced it positively in another way, such as by being more focused when walking. Participants also verbally described what had been reflected in the quantitative data, namely that participation in the programme had positively impacted their confidence and reduced their fear of falling. Another important positive effect, which seems to have received hardly any attention in previous studies, is that participants stated the programme gave them a goal and a reason to go out. Just leaving the house at all will often be beneficial regarding clients' activity levels and social contacts, especially for more vulnerable individuals who might suffer from anxieties or loneliness (Cohen-Mansfield et al. 2016). It is likely that this effect will occur in particular when programmes are very motiving, like the gardening sessions, of which most participants

did not want to miss even one. Another positive effect of participating in the gardening intervention was the better understanding and acknowledgement of the other exercise classes participants engaged in. It is important to highlight that participants did not report disliking standard exercise classes, and that some even preferred their higher intensity levels. However, these classes often remained abstract, and the gardening programme, which also included warming up and cooling down sessions, made them realise why they had learned certain exercises. The movements became more meaningful and more relevant for their daily life.

In addition to these findings relating to the participants' subjective experience, it is also key to pay attention to adherence to interventions when examining the effects of a programme. As Nyman and Victor (2012, p. 17) highlighted: "Regardless of how efficacious an intervention may be, it will have poor effectiveness if older people either decline to participate or do not adhere to the intervention protocol". In the current study, all participants completed all eight gardening sessions and none of them dropped out. Even though the sample was small and the intervention time not very long, this indicates that the programme was very effective in successfully engaging the participants. The participants' ratings of their wish to continue with the programme also clearly support this point. Unfortunately, it was not possible to monitor the recruitment success, since in combination with the strict criterion that participation in the programme should not affect standard clinical care, our findings cannot provide any information on whether participants were more likely to accept an invitation to a gardening fall-prevention group.

Key pillars of the programme

In addition to insights regarding the effects of a gardening programme, our findings also help to understand *why* the programme was so successful in keeping participants engaged. Knowing about these factors is key for increasing acceptability and adherence to programmes (Bunn et al., 2008). Thematic analysis of the participants' experiences revealed what factors facilitated participation in the programme. While two of the factors we found (*Positive group interaction*, *Enjoyment*) overlap strongly with the facilitators Bunn and colleagues (2008) identified ("Emphasis on social aspects of interventions", "Making exercise fun/enjoyable/sociable"), we also found three other important factors: *Feelings of achievement*, *Body and mind*, and *Aesthetic and natural experiences*. All three factors seem to be unique to the gardening setting, as standard exercise settings do not provide the possibility to see one's own achievement, to learn about gardening, and to be outside and perceive colour, taste, smell, and the touch of plants and their products. Taken together, these five factors highlight that older adults do not only want to train physical strength and abilities. Participants in our study liked and wanted to learn applicable, and practical gardening and movement knowledge, meet and interact with others, enjoy themselves, see what they achieved, be in touch with nature, use cognitive skills, and stimulate their mind. Cognitive and mental stimulation can also be promoted in different ways in fall-prevention programmes, for instance by means of obstacle avoidance task mimicking activities of daily life and additional cognitive tasks (Weerdesteyn et al. 2006). Yet these methods still lack many of the other identified motivating factors.

Participants furthermore highlighted that it was very important for them that their special needs, strengths, and limitations were considered, that there was thoughtful preparation of the gardening site and the gardening session, and enough support staff members and fall-prevention experts to feel safe. Bunn and colleagues (2008) also identified several facilitators which relate to this point, such as personalised modifications, good leadership/facilitation, and programmes tailored to needs or lifestyle. We listed the *Special needs of the target group* as specific theme and factor which needs to be considered, and not just as part of the motivational facets,

as it seems to be a fundamental pillar of the gardening programme's success. All in all, our results show that a gardening programme constitutes multiple and partly unique motivating factors which could increase intervention adherence and thus also the effectiveness of a programme (Nyman and Victor 2012).

Feasibility and sustainability of the programme

Since no fall-prevention gardening intervention programmes have been scientifically evaluated and described to date, this study provides important insights into the feasibility of such a programme (Chen and Janke 2012). When examining the practicalities of the programme, it becomes quickly apparent that running such a programme requires a lot of preparation and a large number of supporting staff members. It also needs gardening material and equipment, and gardening expertise when designing the gardening site and the sessions for the first time. However, considering the personal and societal costs related to falling, clinical treatment, and possible further functional decline, the costs for such a gardening programme will probably still be lower (Pereira et al. 2008), especially when considering that such a programme could have lower dropout rates and reach clients who might otherwise decline to take part in any fall-prevention classes. Furthermore, no falls and only one near-miss occurred in the gardening groups. While falls related to an exercise intervention or study participation occurred in other studies too, many studies do not report near-misses, so it remains unclear whether participation in the gardening programme was riskier than participation in other exercise programmes (Weerdesteyn et al. 2006; Siegrist et al. 2016; Lamb et al. 2020). In the targeted population, falls can occur in any type of intervention which includes partially challenging activities. Thus, when appropriately prepared and supervised, the fall-prevention gardening programme seems to be a feasible alternative to traditional types of exercise and could surely at least complement conventional fall-prevention offers.

Considering the strong wish for a continuation of the programme we saw in participants, it would be advisable to run a regular, professionally supervised gardening group, as is also sometimes seen in hospitals or nursing homes (Raske 2010). However, it must be taken into consideration that safety is an important concern, and the provision of professional support is key. The inability to ensure such professional support on the gardening site after the funding period for the current project ended unfortunately also meant that the groups were not continued, as originally hoped for. For the university the risk of adverse events was too high and the IFBHS no longer had the capacity to supervise the sessions at an external location. The gardening site continued to be used by the university's "[*name deleted for review*]" team as a location for growing sustainable produce, but attempts to open up the space for clinical groups did not succeed. By teaching the participants how they could garden safely and comfortably, they were however empowered to also engage in gardening activities at home. This can be seen as a contribution to the sustainability of such an intervention, yet, it needs to be highlighted that not all people have access to gardens. Ideally, everybody should have access to a garden which is suitable for the target group and publicly available, but unfortunately the current project did not succeed in creating such a space in a sustainable way (Buck 2016).

Strengths and limitations

The current study is the first clinical trial testing the effects of a gardening intervention. All in all, the findings provide promising evidence for positive effects of the intervention and for the feasibility of a fall-prevention gardening programme. Our findings highlight the unique chances a gardening programme can offer, including high attractiveness for a diverse target group, stimulation of positive physical, social, cognitive, and affective states, and the empowerment of participants. By using a mixed-methods approach, we were able to provide useful and detailed insights for professionals who want to implement a gardening group for an older

adult population in general, and in particular older adults at risk of falling.

However, the current findings need to be interpreted in light of the study's limitations. The biggest limitation of the current study was the small number of participants. We aimed at 30 participants, but realised that we could not accommodate more than 16. Therefore, our study was underpowered and we were not able to draw robust statistical conclusions. Furthermore, due to ethical and resource-related limitations, the current study did not use a control group and there was no long-term fall assessment. We cannot therefore draw conclusions regarding the effectiveness for the prevention of falls, and the effects we found could in theory also be the result of general treatment effects. Making use of long-term assessment, including a control group and randomisation in the future, would therefore significantly advance the current evidence, although the qualitative findings of our study do imply that the effects of the intervention were closely linked to the actual gardening activities, and not just to general intervention effects. It is also an important limitation of the study that not every older adult at risk of falling was eligible to participate. Eligible participants were those able to mobilise without walking aids, with no known diagnosis of dementia, and who had already completed standard fall-prevention classes, were awaiting participation in these classes, or had rejected invitations to such classes. This was done so as to not affect any existing standard clinical care. Our findings can thus not be generalised to all older adults at risk of falling. Lastly, the study does not provide insights into acceptance rates for a gardening fall-prevention programme.

Conclusion

Overall, a gardening programme seems to be a promising fall-prevention intervention for older adults at risk of falling, but who can move freely on a gardening site designed for this target group. The intervention programme was perceived very positively by all involved parties, namely participants, student volunteers, and staff members, and participants reported various positive changes. However, future studies need to further investigate the effectiveness of the programme, ideally using an RCT design and larger sample sizes. Apart from the study's relevance regarding gardening interventions, our findings highlight factors which could be systematically targeted to further increase participants' motivation, acceptance, and adherence rates to fall-prevention programmes (Bunn et al., 2008). It seems to be advisable for programme makers to pay more attention to the identified factors, such as by allowing more space for interpersonal exchange, or instigating physical as well as mental training and learning. The findings of our study imply that participants appreciate a purposeful and more holistic programme which gives them a sense of achievement, which has social, cognitive, and perceptual facets, and which also stimulates their physical capabilities.

Declarations

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Conflicts of interest/Competing interests: The authors have no relevant financial or non-financial interests to disclose.

Ethics approval: This study was performed in line with the principles of the Declaration of Helsinki. The study received approval by the Health Research Authority (HRA; NHS England) and the HRA Research Ethics Committee (REC reference number: *[removed for review]*).

Consent to participate: Informed consent was obtained from all individual participants included in the study.

Consent for publication: NA

Availability of data and material (data transparency): Questionnaire items and quantitative raw data without any personal information are available via the OSF (*[link removed for review]*). Detailed intervention material can be found in the Supplementary online material.

Code availability (software application or custom code): NA

Author contributions: All authors contributed to the study conception, the study design, and the implementation of the intervention. All authors contributed to material preparation, and data collection. The funding acquisition, ethical approval procedure, and the overall execution of the project was led by *[removed for review]*. *[removed for review]* headed the participant recruitment, created the intervention content, and led all intervention sessions. *[removed for review]* performed the data analysis and wrote the first draft of the manuscript. All authors contributed to the final version of the manuscript and read and approved the final manuscript.

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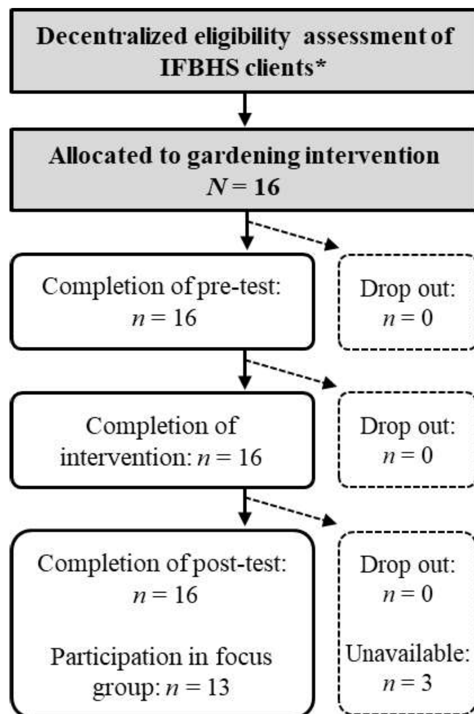
Figure 1

Flow diagram documenting the flow of participants through the trial



IFBHS = Integrated Falls and Bone Health Service

* Recruitment had to take place in the field and was conducted by staff members of the IFBHS team as part of their daily work with and intake of clients. Due to the decentralised approach, we are unable to provide reliable information regarding the number of clients who were screened and/or assessed for eligibility.

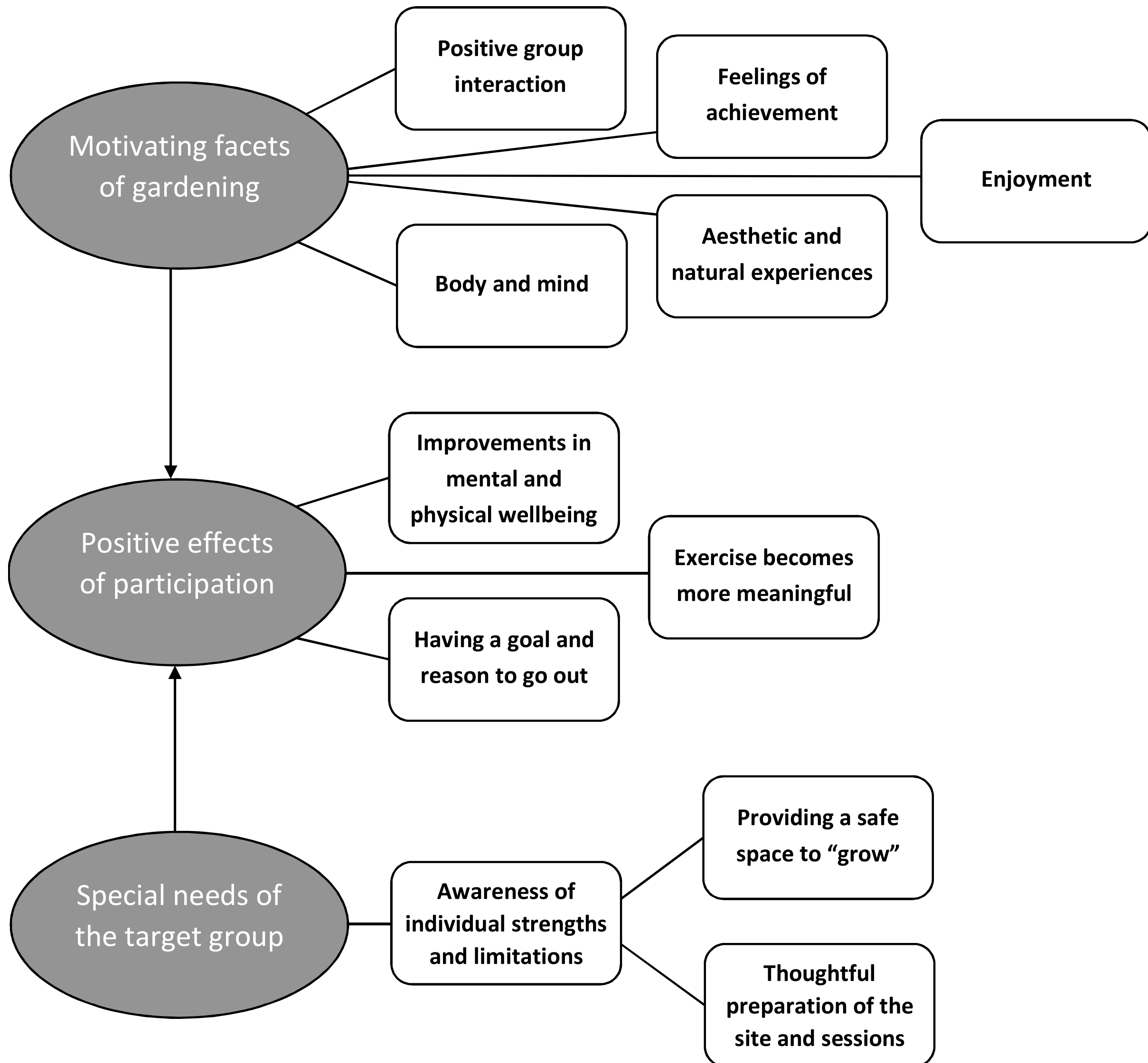
Figure 2

Pictures of the gardening site at the University of [name deleted for review] campus before the programme (February 2017, left picture) and after the programme (August 2017, right picture)

Additional colour pictures can be found in Supplementary Figure 1.

1 **Figure 3**

2 *Themes (in grey) and subthemes (in white) identified in the thematic analysis*



3

Table 1

Summary of the changes from pre- to post-measurement

		Before intervention Mean	*SD*	After intervention Mean	*SD*	*p* (two-tailed)	Effect size
Physical outcome measures	Up and go[a]	12.88 s	3.90	12.07 s	3.93	.282	d_z = -0.28
	Turn test	4.75 steps	1.06	4.31 steps	0.70	.156	*r* = -0.50
	Sit-to-Stand[a]	9.00 times	3.20	9.31 times	3.05	.552	d_z = -0.15
Health (EQ-5D index score)		0.78	0.14	0.82	0.15	.078	*r* = -0.34
Wellbeing[a] (WEMWBS)		3.90	0.76	4.08	0.79	.069	d_z = -0.49
Fall efficacy (FES-I[b])		29.59	9.21	29.44	9.34	.801	*r* = -0.05
General self-efficacy[a]		3.18	0.48	3.21	0.57	.762	d_z = -0.08
Social connectedness[c]		5.18	0.98	5.35	0.81	.320	*r* = -0.25
Fear of falling[a]		4.00	2.00	3.38	2.47	**.028**	d_z = 0.61
Confidence goal achievement		7.25	1.51	8.47	1.54	**.005**	*r* = -0.53

Note: The white, grey, and dark grey part of table reflect the primary, secondary, and exploratory outcome measures respectively; WEMWBS = Warwick-Edinburgh Mental Wellbeing Scale, FES-I = Falls Efficacy Scale-International, *SD* = standard deviation, s = seconds; *p*-values below the significance level of .05 are highlighted by bold print; effect size calculation as in Lakens (2013) and Field (2018)

[a] T-tests were used for analysis; all other variables were analysed using Wilcoxon signed rank test; [b] Values above 28 were classified as high concerns for falling; [c] *n* = 14 due to missing values

Blinded Manuscript with changes highlighted Click here to view linked References

A mixed-method exploration of the effects and feasibility of an intergenerational fall-prevention gardening programme in older adults at risk of falling: A clinical trial

Running title: EFFECTS OF A FALL-PREVENTION GARDENING PROGRAMME

Declarations of interest: none.

Abstract

Aim: Exercise-based fall-prevention programmes can significantly benefit older adults at risk of falling, yet drop-out and non-adherence are common. The current study investigated the feasibility and effects of an intergenerational, gardening-based fall-prevention programme. This intervention was chosen because gardening is known to have a multitude of positive effects and was considered as an attractive option for the target population.

Subject and Methods: Across three months, 16 individuals at risk of falling participated in eight weekly gardening sessions. Participants completed a battery of physical assessments and self-report questionnaires before and after the intervention. Focus groups were used to explore the participants' perceptions of the intervention.

Results: No statistically significant changes for the main physical and mental health outcomes were found, but participants reported increased confidence and reduced fear of falling. Qualitative analyses revealed that participants perceived the intervention to have diverse positive effects and provided important insights into participants' motivation for programme attendance.

Conclusion: A professionally designed and supervised gardening programme seems to be a promising fall-prevention intervention and adequately powered RCTs need to further examine the effectiveness of such programmes. Furthermore, the current findings have a high value for researchers and practitioners, as they highlight factors like purposefulness and cognitive stimulation which could be systematically targeted to further increase participants' motivation, acceptance, and adherence rates to fall-prevention programmes in general.

Trial registration number: ClinicalTrials.gov, *[number removed for review]*

Keywords: gardening, fall-prevention, qualitative methods, clinical trial

A mixed-method exploration of the effects and feasibility of an intergenerational fall-prevention gardening programme in older adults at risk of falling: A clinical trial

Falls and the fear of falling have been identified as a major health problem in the older population (Pereira et al. 2008; Montero-Odasso et al. 2021). While engagement in physical activity has been found to prevent falls, older adults who fell in the past and/or who experience a fear of falling often restrict their physical activities, especially when suffering from poor health (Pereira et al. 2008; Jenkin et al. 2017). This can lead to further functional decline, reduced mental health and social contact, and ultimately an earlier ageing institutionalisation (Pereira et al. 2008). Exercise-based fall-prevention classes have been found to effectively prevent falls, to increase physical activity levels, and to benefit multiple health outcomes (Gillespie et al. 2012; Montero-Odasso et al. 2021). Siegrist and colleagues (2016) for instance conducted a randomised controlled trial (RCT) with more than 370 participants, of whom 222 participated in an exercise group for 16 weeks. They found that the exercise programme led to significant reductions in the number of falls and fallers over a period of 12 months. Furthermore, only the exercise group showed reduced incidence rates of fall-related injuries and a reduced fear of falling, as well as improved physical functioning. Notwithstanding the effectiveness of such programmes, a high number of older adults at risk of falling are not willing to partake, as evidenced by acceptance rates of on average only 64% to exercise-based fall-prevention interventions in community settings (Nyman and Victor 2012). This lack of programme acceptance poses a big challenge in the field and warrants more fitting interventions, as well as a better examination of older adults' views about fall-prevention programmes (Bunn et al. 2008). The current study will pursue these goals by systematically examining the effects, feasibility, and participants' perceptions of an alternative, gardening-based fall-prevention program.

When examining the evidence on existing fall-prevention programmes, it becomes apparent that exercise-based fall-prevention programmes mostly consist of strength training and activities targeting balance, for instance walking, Tai Chi, or dancing (Bunn et al. 2008; Chen and Janke 2012). However, a review of facilitators and barriers to fall-prevention programme participation found that older adults who had not exercised at a younger age were less likely to participate in these typical exercise programmes. This was partly explained by the absence of exercise habits, the expectations of discomfort, and the perception of a misfit with one's personality or abilities (Bunn et al. 2008). Kirchhoff and Damgaard (2016), who investigated the uptake of and adherence to fall-prevention programmes in general, found furthermore that programme offers or referrals were often refused because potential participants were not interested or reported to not have enough energy. In line with these findings, the healthcare practitioners involved in the research project described in the current article heard from clients that they had no interest in standard exercise classes, like Nordic walking. Instead, several clients expressed a wish for more meaningful alternative exercise forms, an observation Åhlund and colleagues (2020) also reported for frail older adults with a severe comorbidity burden. Regarding potential facilitators for programme uptake, Bunn and colleagues (2008) furthermore found that the experience of social support and interaction, low to moderate intensity activities, and exercises tailored to the individuals improved adherence.

A type of exercise which connects to these facilitators and which at the same time mitigates all of the above-mentioned barriers to exercise-based fall-prevention programmes is gardening. Firstly, gardening is one of the most popular physical activities persons engage in during their leisure time (Ham et al. 2009). It is thus likely that older adults have engaged in gardening at some point of their life. For clients who have no earlier exercise history, gardening consequently represents a familiar activity pattern, and they might be more likely to participate in a gardening-based fall-prevention programme (Chen and Janke 2012). Secondly, gardening is

generally perceived as an enjoyable, purposeful, and meaningful activity (Patil et al. 2019; Åhlund et al. 2020). Thirdly, the tasks gardeners typically engage in, such as potting plants, watering, or harvesting, can provide specific physical health benefits by targeting balance. They also encompass different low to moderate intensity movements (Chen and Janke 2012; Park et al. 2015). Furthermore, when done in a group, these activities require cooperation and provide opportunities to support each other, share experiences, and connect to others (Wang et al. 2015). An inclusion of different generations in gardening programmes can even facilitate the connection between different generations and provide older adults with opportunities to convey knowledge (Brown et al. 2020; Jakubec et al. 2021). Thus, a group gardening programme could offer opportunities to promote social support and interaction, while gardening is well suited to tailor exercises to individuals – factors which have all been found to increase the acceptability of an exercise-based fall-prevention programme (Bunn et al. 2008; Chen and Janke 2012).

In addition to the unique appeal of gardening to the population of older adults, it has been shown that gardening in general has a multitude of positive effects on wellbeing and health (Van Den Berg and Custers 2011; Hawkins et al. 2013; Wood et al. 2016). These benefits include improvements in life satisfaction, positive affect, and quality of life along with a reduction in factors such as stress, anger, depression, and anxiety (Gigliotti et al. 2004; Wakefield et al. 2007; Wilson and Christensen 2012). Specifically within the older adult population, gardening has also been shown to promote higher levels of self-efficacy, self-esteem, and feelings of mastery, accomplishment, and competence (Wang and MacMillan 2013; Thompson 2018). Additionally, sole exposure to green environments, contact with nature, and physical activity outdoors have on their own also been found to be restorative and to increase health and wellbeing levels (Barton et al. 2016; Patil et al. 2019).

Considering the evidence reviewed above, it is no surprise that health professionals recommend to include gardening as a treatment option for clients whenever possible, as is already common practice in occupational therapy (Barton et al. 2016; Patil et al. 2019). However, this recommendation has not yet been adopted in the field of fall-prevention, even though Chen and Janke (2012) already hypothesised that gardening interventions could be very suitable to prevent falls. The authors based this conclusion on the findings of a large-scale (N = 3,200) cross-sectional study, showing that older individuals engaging in at least one hour of gardening per week had a better health status, better balance, and faster gait speed. They had furthermore fallen less often in the previous two years than individuals who did not engage in gardening that much. Even though the authors did not find gardening to be a significant predictor of falls when controlling for health and fall risk factors, they suggest that gardening can influence the fall risk through its effect on factors such as health status, balance, and gait speed. Chen and Janke (2012) therefore call for a carefully planned integration of gardening into fall-prevention interventions, ideally as a professionally monitored group-based gardening program, as group-based programmes appear to be more effective in general. Yet, despite the diverse support for gardening as an exercise-based fall-prevention programme, up to today there have been no systematic assessments of such interventions.

The current study therefore set out to for the first time systematically investigate the effects and the feasibility of a gardening-based fall-prevention programme. More specifically, it examined the hypotheses that regular participation in a group-based, intergenerational gardening programme would lead to improved physical and mental health outcomes, a reduced fear of falling, and enhanced physical activity levels, self-efficacy, and social connectedness in older adults at risk of falling. We additionally explored other beneficial effects, and the feasibility and sustainability of the programme, by examining falls and incidents and by investigating the subjective experiences of participants. The aim of the study was also to share useful empirical and practical

information to inform professionals in the field who are considering implementing a similar gardening programme. It should reveal whether gardening might offer a suitable alternative to standard exercise classes.

Methods

Study design

The study was a single-arm clinical trial and thus encompassed one gardening intervention group. It was not possible to include a control group as this would have affected the existing clinical care that participants were receiving. Due to limited resources, it was also not possible to implement a wait list control group as there was only funding to run the gardening programme once. The study was registered as a clinical trial (ClinicalTrials.gov identifier: *[number removed for review]*) and received approval by the Health Research Authority (HRA, National Health Service England) and the HRA Research Ethics Committee. Gardening groups were offered twice per week for three months, and each participant attended a total of eight gardening sessions, one per week, across this time period. The study aimed to explore the potential effects and feasibility of a new and innovative gardening intervention, although it was not planned to function as a feasibility study for a larger randomised controlled trial.

Participants

Participants were recruited from a pool of older adults who had completed a Falls and Bone Health Assessment with a specific *[number removed for review]* borough's Integrated Falls and Bone Health Service (IFBHS). In the following, these older adults will be referred to as clients. Only clients who had declined to take part in the usual prevention exercise programmes, and clients who had either completed or who were awaiting usual prevention classes were offered to participate in the project. This was done so as to not affect any existing, standard clinical care that participants were receiving. Clients furthermore needed to be able to mobilise without walking aids since the use of ambulatory assistive devices was not possible on the gardening site. Further exclusion criteria were having a known diagnosis of dementia, not being able to adequately understand verbal explanations or written information given in English, and having a high falls risk profile in a gardening context, as assessed by a clinical decision based on mobility and general health made by professionals of the IFBHS.

Recruitment took place via several staff members of the IFBHS who, as part of their normal care, informed eligible clients about the gardening programme and the associated study. We originally aimed to recruit 30 participants since a priori power analyses indicated that a total sample size of $N = 27$ participants would be needed for a paired t-test to detect an assumed medium sized effect (Soga et al. 2017) with a power of .80 and an alpha error probability of 0.05. However, the original target number of 30 participants had to be abandoned, as it became apparent during the first weeks of the project that it was not feasible to offer more than two gardening groups per week, and that no more than eight clients could participate per session to ensure health and safety. We originally planned to run three groups with ten clients per group. However, it soon became apparent that the amount of work in a garden, which needs time to grow, is limited. Although some extra tasks were added, such as building bird scarers, participants preferred to work with the plants and soil. Furthermore, the size of the garden made it difficult for more than eight participants to safely move around the site while receiving sufficient supervision from healthcare professionals and individual support from students and staff members. Apart from that, more staff members/volunteering students were needed than originally anticipated. The most comfortable clients to staff/volunteer ratio turned out to be between 2:1 and 1:1, depending on the participants' needs. Thus overall, 16 eligible clients were finally recruited (56% males; mean age = 77 years, age range = 59–89, of whom 75% had engaged in gardening activities before; one participant attended a standard

exercise-based fall-prevention class during the first week of the intervention). All participants took part voluntarily, provided written informed consent, and were advised of their right to discontinue the study at any time as well as to withdraw their consent afterwards. All 16 participants who started the programme completed it. However, due to the decentralised recruitment approach, we are unable to provide reliable information regarding the number of clients who were originally screened and/or assessed for eligibility (see Figure 1).

Intervention

From June to August 2017, two gardening groups with up to eight clients and about four to six supporting students/staff members per group were offered weekly. Participants were asked to attend the one-hour long gardening sessions for a total of eight times within a time span of three months to allow for sickness/personal reasons for non-attendance, and cancellations due to bad weather conditions. The gardening intervention took place at a gardening site on the campus of the University of [*University name removed for the review process*]. Guidance on the prevention of falls in older people by the National Institute for Health and Care Excellence suggests that fall-prevention programmes should be flexible enough to accommodate different needs and preferences, and that programmes should also have a social value (NICE 2013). As the University of [*University name removed for the review process*]'s campus is located in an area with a high density of social housing, we anticipated that an intergenerational gardening project, where older people from the community come together with student volunteers, would attract and benefit a diverse group of participants, including people whose fall risks are related to social isolation, the built environment, and other social and mental health risk factors.

The gardening site was purpose-built for the study, including the installation of two ground-level and six 2x1m raised beds to allow for gardening activities at comfortable working heights and to meet different physical needs (see Figure 2 and Supplementary Figure 1). All groups were led by an IFBHS exercise facilitator and an occupational therapist and were supported by university staff and student volunteers. Each intervention session was designed to accommodate relevant activities for the then-current point in the growing season and the development of the gardening site (i.e. what had grown, what could be sown or harvested, what needed further development/building); each session also accommodated the needs and status of the attending participants concerning their overall health state, their acute health state, and possible preferences for certain gardening activities. All gardening tasks were individually tailored to the participants by planning, adapting, and grading each task to ensure the core principles of strength, power, balance, and coordination were challenged to an appropriate level. A summary of the sessions and main gardening tasks used throughout the weeks, as well as the criteria for the newly built gardening site can be found in the online supplementary material.

Measurements

Immediately before starting the first gardening session and on the day of the last gardening session, all participants completed a pre-intervention (T1) and a post-intervention (T2) assessment which lasted 15-20 minutes. In this assessment, participants completed several questionnaires and functional mobility tests related to their fall risk factors in order to assess the primary and secondary outcome measures. Furthermore, subjective experiences participants made in the gardening programme were explored by means of brief individual questions and two focus groups after completion of the programme.

Primary outcome measures

Physical mobility tests

Physical risk factors of falling were assessed by means of three different mobility tests which ran in the following order: a) Timed Up and Go Test (Podsiadlo and Richardson 1991): time in seconds needed to stand up

from a standard armchair, walk to a line that is 3 meters away, turn around at the line, walk back to the chair, and sit down; b) Timed 180° Turn Test (Robinson and Ng 2018): Number of steps required to turn in a half circle (180°); c) 30-second Sit-to-Stand Test (Jones et al. 1999): Number of complete chair stands (up and down equals one stand) completed in 30 seconds.

Health and wellbeing

Health was assessed via the EQ-5D-5L questionnaire (Herdman et al. 2011) which measures five dimensions of health, namely mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. For each health dimension, participants could choose from five response categories corresponding to "no problems", "slight problems", "moderate problems", "severe problems" and "extreme problems/inability". A response category for mobility was for instance: "I have no problems in walking about". Respondents were asked to choose the response that best described their health on the day of the measurement. The weighted index value, or EQ-5D health score, for the five dimensions was calculated for each participant, with higher values representing a better health status; the theoretical score ranged between worst health = -0.29 and best possible health = 1. Furthermore, the probability of improvements due to the intervention was examined for each dimension by means of the so-called Probability of Superiority measure (computed as follows: [# participants with positive change+0.5*# participants with no change]/# participants). Values above 0.5 indicated better health levels while values below 0.5 reflected worse health levels after the intervention compared to before the intervention (Devlin et al. 2020). The internal consistency of the scale was satisfactory at T1 and T2, with a Cronbach's alpha of .73 and .76 respectively (Seng et al. 2020).

Wellbeing was measured by means of the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (Tennant et al., 2007). The scale consists of 14 items which cover hedonic and eudaimonic aspects of mental health. Respondents rated their experience over the last two weeks on a 5-point-scale ranging from "none of the time" to "all of the time". An example item is "I've been feeling relaxed". We computed the mean value for each participant, with higher mean values indicating better levels of wellbeing. The internal consistency was very good at both T1 and T2, with a Cronbach's alpha of .94 and .96 respectively.

Fall efficacy

Perceived self-efficacy at avoiding a fall was assessed via the 16-item Falls Efficacy Scale-International (FES-I) (Yardley et al. 2005). Respondents rated their concerns about the possibility of falling in different situations, such as when "preparing simple meals", on a 4-point-scale ranging from "not at all concerned" to "very concerned". Sum scores were calculated, with higher scores reflecting higher levels of concerns about the possibility to fall. The internal consistency was very good at both T1 and T2, with a Cronbach's alpha of .91 and .93 respectively.

Secondary outcome measures

Falls and incidents

Participants indicated at T1 whether any falls had occurred in the last eight weeks in order to obtain a falls baseline measure. At T2, participants reported the number and location of falls which had occurred in the weeks since they had started the gardening intervention. To judge the programme's feasibility and risks, the number of falls or other incidents, such as near misses, during participation in the actual gardening sessions were also systematically recorded.

Activity levels

Changes in activity levels were assessed descriptively by asking participants the following question at T2: "Have you noticed any changes in your activity levels since the gardening programme has started?". The answers were coded as -1 (activity levels decreased), 0 (no change), 1 (activity levels increased), and 2 (no change, but positive physical and/or psychological changes).

General self-efficacy

General self-efficacy was measured by means of the Generalized Self-Efficacy Scale (Schwarzer and Jerusalem 1995). The scale consists of 10 items with a 4-point answer scale ("1 = not at all true" to "4 = very true"). An example item is: "I can always manage to solve difficult problems if I try hard enough". Higher values represent higher general self-efficacy levels. The scale's internal consistency was good and very good at T1 and T2, with a Cronbach's alpha of .84 and .93 respectively.

Social connectedness

Social connectedness was measured by means of the Social Connectedness Scale (Lee and Robbins 1995). The scale consists of eight items with a 6-point answer scale ("1 = strongly agree" to "6 = strongly disagree"). An example item is: "I feel disconnected from the world around me". Higher values represent higher social connectedness levels. The scale's internal consistency was good and very good at T1 and T2, with a Cronbach's alpha of .96 and .86 respectively.

Exploratory outcome measures

The survey also included two single items about *Confidence in achieving goals* and *Current fear of falling* as these are part of the standard IFBHS questionnaire. Respondents gave an answer to the question "How confident are you to achieve goals (on a scale from 0 to 10)?", and were asked to rate the extent of their fear of falling on an 11-point scale (from "0 = no fear" to "10 = terrified" (Denkinger et al., 2009). As these items were not officially preregistered, they are treated as exploratory outcome measures.

Participants' subjective experiences of the programme

At the end of the gardening programme, participants' subjective experiences of the gardening programme were assessed. First, participants shared their experiences individually in the T2 survey by answering four questions: a) how much he/she had enjoyed participating in the gardening programme, and how much he/she would like to continue attending a gardening group at *[name deleted for review]* campus (each question rated on a scale from "0 = not at all" to "10 = very much"); b) how he/she would summarise their experience in the gardening programme in one or two sentences, and what he/she had liked most and had not liked about the gardening programme. The answers to the open answer questions were summarised and written down by the investigator who completed the questionnaire with the participant; all answers can be found in Supplementary Tables 2 and 3. As a second assessment, two semi-structured focus groups were conducted. Participants were asked to discuss what they had liked/disliked about gardening and the gardening project (also in comparison to the standard exercise classes), whether they had experienced any changes in themselves during the programme, and what their opinions about possible barriers to continued engagement in such a programme were.

Data analyses

Due to the small sample size, all quantitative variables were checked for normality using the Shapiro-Wilk test. Changes in variables which were identified as being non-normally distributed, namely the Timed 180° Turn Test, EQ-5D health score, FES-I fall efficacy, goal achievement confidence, and social connectedness, were analysed by means of the Wilcoxon signed rank test for exact significance for related samples. Median instead of mean scores were reported for these variables. T-tests for paired samples were used to analyse changes

in normally distributed variables, namely the Timed Up and Go Test, 30-second Sit-to-Stand Test, wellbeing score, fear of falling, and general self-efficacy. For null hypothesis testing, the level of significance was set at $p < .05$. All data were analysed using SPSS Statistics 27.

The focus groups were transcribed verbatim (omitting utterances like uhm and ahs). Grammatical mistakes or redundant words were not corrected to allow the reader to better empathise with the speakers. The focus group transcription as well as the summary to the open answers in the questionnaire were analysed using a theoretical thematic analysis at the semantic level. We used a realist thematic analysis approach, as the goal of the analysis was to reflect participants' motivations, experience, and meaning by describing, summarising, and interpreting patterns in semantic content (Braun and Clarke 2006). Coding was done using the programme ATLAS.ti.

Results

The results (mean [*M*] or median [*Md*], standard deviation [*SD*], *p*-value, effect size) for all quantitative primary and secondary outcome measures are depicted in Table 1. On a descriptive level, all changes observed from T1 to T2 reflect improvements.

Primary outcome measures

Statistically significant changes from T1 to T2 were not found for any of the three physical outcome measures *Timed Up and Go Test*, *Timed 180° Turn Test*, *30-seconds Sit-to-Stand Test*), nor for *Health*, *Wellbeing*, or *Fall efficacy* levels (all $p > 0.05$; see Table 1). Even though not statistically significant when testing the null hypothesis, medium to large effect sizes emerged for the Timed 180° Turn Test and for changes in well-being. For health, the probabilities of superiority for each of the five EQ-5D dimensions were: mobility = 0.56; self-care = 0.53; usual activities = 0.56; pain/discomfort = 0.66; anxiety/depression = 0.47.

Secondary outcome measures

No statistically significant changes from T1 to T2 were found for the main quantitative secondary outcome measures *general self-efficacy* and *social connectedness* ($p > 0.05$; see Table 1). The number of *falls and incidents* showed that no additional risk seemed to be related to participation in the gardening programme. In total, one subject reported one fall for the eight weeks before the start of the intervention and another person reported one fall for the time that the gardening intervention lasted, the latter fall not being related to the gardening sessions. During the gardening intervention, no falls and one near miss occurred when a participant lost his balance while digging and was supported by a support staff member to regain his balance.

The descriptive analysis of reported *activity levels* showed an increase for seven of the 16 participants. Five participants reported other positive changes related to engaging in physical activity, such as being more focused when walking, which meant being more confident. Three participants did not report any changes in their activity levels. One participant reported that his/her activity levels reduced, but clearly attributed this to a fall which occurred in the weeks during which he/she participated in the gardening intervention (see Supplementary Table 1 for all responses).

Exploratory analyses

Considering the descriptions of positive changes which were noticeable in the data, we questioned whether the scales we had chosen for the assessment of the interventions might not have been sensitive enough to detect change considering the low power our study had (Ching Ting Fok and Henry 2015). In line with Preston's and Colman's (2000) findings, we assumed that the 11-point scales which were included in the standard IFBHS questionnaire could provide participants with a better opportunity to express changes and thus

also analysed pre-post changes for both scales. For the extent of the *current fear of falling*, a statistically significant decrease was observed ($t(15) = 2.44$, $p = .028$, $d_z = 0.61$). After completion of the intervention, participants reported to be less fearful of falling ($M = 3.38$) than before the intervention ($M = 4$). The resulting effect size of $d_z = 0.61$ reflected a medium to large effect. The *confidence to achieve goals* increased significantly ($Z = -2.604$, $p = .003$, $r = -0.53$). After the intervention, participants were more confident in achieving goals ($Mdn = 9$) than before the intervention ($Mdn = 7.5$). The size of this effect was moderate.

Participants' experiences

Participants thoroughly enjoyed participating in the programme. This was reflected in the answers they gave in the survey (see Supplementary Table 2) and in the two focus groups (one with six and one with seven participants), as well as in their enjoyment ratings of the programme ($M = 9.22$, $SD = 0.88$ on a 0–10 scale). In line with these positive experiences, almost all participants indicated that they would strongly like to continue attending the gardening group ($M = 9.25$, $SD = 1.40$). When asked what they did not like about the programme, no generally negative points emerged. One individual did not really like the kneeling, another would have liked to see more physical change. The criticism which was mentioned most often was that the group should have lasted longer than just one hour (see Supplementary Table 2).

Apart from the outcomes assessed by means of physical tests, questionnaires and interviews, participants also voted with their feet: The study had a retention rate of 100%. All sixteen participants adhered to the gardening programme with no drop-outs, and everyone that completed the requested eight weeks of the programme before the official end date wanted to attend the gardening sessions beyond that point until the project had ended. Participants came in warm as well as in rather cold weather, and were not even put off by forecasted showers.

Thematic analysis

In addition to giving insights into what participants liked and disliked about the programme, the results of the thematic analysis describe what participants experienced throughout the programme. Three main themes were identified in the analysis of the focus groups and the open answer questions. First, the *motivating facets of the gardening programme*, second, the *special needs of the target group* which needed to be considered, and third, the *positive effects of participation* in the programme which emerged (see Figure 3). For each theme, several subthemes were identified, which will be briefly described below. The order of subthemes in which they are discussed does not reflect any differences in their importance. A more detailed table with several quotes for each subtheme can be found in the Supplementary Tables 4a, 4b, and 4c.

Motivating facets of the gardening programme

This theme describes the aspects which motivated participants to engage in the gardening sessions. The first of its five subthemes is *Positive group interaction*. This subtheme reflects that participants reported that the possibility to meet (like-minded) people regularly was very much appreciated by them. It allowed them to communicate with others and learn with and from others, and they liked being part of a team working together towards a goal. As participant 1 from the Wednesday group put it: "It's nice on Wednesdays I know when I come here, to be with very nice people" (Participant Wednesday #1; PW1).

The second subtheme was *Feeling of achievement*. Participants described that mastering the sometimes challenging gardening activities gave them a feeling of achievement, especially considering potentially limiting disabilities. This feeling of achievement was also supported by the fact that they were able to see what they had done throughout the weeks, and that they had also received products of their hard work: "Knowing you can do

something and it might just be, if I wanted to perhaps just grow a little bag of tomatoes. Even if it's just that, from here on in it's something. And you can watch it grow. And you got the end result as everybody said. It's a sense of achievement, isn't it?" (Participant Tuesday #6; PT6).

Body and mind was the third subtheme. Many participants reported they liked that the gardening sessions stimulated them mentally as well as physically. On the one hand, it allowed them to learn something new as participants were in touch with younger people, and because they acquired new knowledge about right movements, as well as about gardening, for instance regarding plants, tricks for older gardeners, and bed setups. On the other hand, most participants increased their activity levels, partly also because they had to walk to the gardening site. As participant W6 stated: "And also, many older people don't get to see younger people. I do think the generational thing can be physically but also emotionally and mentally stimulating for both. […] I can't stress enough, the emotional and mental benefits of it [gardening]. Of keeping the mind, you know, you learn more skills – physical skills – and you learn more knowledge, and the two of them are still, you know, helping the brain. Hopefully keeping Alzheimer's at bay". While gardening was by some described as less intense than standard exercise classes, it was also perceived as requiring more full bodily engagement.

The fourth subtheme was *Aesthetic and natural experiences*. Participants enjoyed to use different senses, for example, when seeing the colour of plants, tasting products, touching the soil, and being outdoors. They also liked to plant seeds and see how plants grow – an experience which cannot be achieved in standard exercise classes, as the following quote shows: "Exercise has for me a more rigid structure and no doubt based on the trainer's experience and your ability and the duration which you are going to do this. That's a different motivation. It's not as aesthetically pleasant as strolling around in the garden and poking at the soil. Eating tomatoes, checking out the colour, it's a different human experience – they're very different" (PT3).

The final subtheme which we identified was *Enjoyment*. Gardening was perceived as very pleasurable, for some more so than standard exercise classes, while for others it was comparable. Many of the above described aspects of gardening led the participants to enjoy themselves, especially the positive interaction in the group and the opportunities to learn. It was also experienced positively that the exercise felt more natural: "You're enjoying moving around more. It doesn't seem like an exercise because you're enjoying yourself" (PT7).

Special needs of the target group

This theme summarised how the participants felt that their special needs were taken into account in order to enable them to complete the programme. The first subtheme on which the other two subthemes seem to base was *Awareness of individual strengths and limitations*. Participants highlighted several times that it was important that staff members involved in the programme were aware of their personal health issues, their different (dis-)abilities, and their individual needs, such as those regarding safety measures or support: "People, they were very helpful, and they were watching you. Because some people are less able. Cause, I've got one leg that isn't quite, that is very weak. And they were very aware and, yeah. It was very good" (PT2).

The second subtheme *Thoughtful preparation of the site and sessions* builds onto this need for individual attention. It reflects the statements participants made regarding the importance of a gardening programme which was tailored to their needs. This relates both to the actual growing site and equipment, such as having raised beds, kneelers, and a bench in the shade, as well as to the activities done in each gardening session, which had to suit the season, the state of the plants, as well as individual needs and goals. This preparation, which was only possible due to the combination of physiotherapy and gardening knowledge in the person of ST, enabled participants to (re-)discover gardening activities: "I think, which I found is that it's well organised they tell you

what tasks are on today and let you work at your pace, no pressures, no, you know, you do things you want to do – in your own pace. And there are things that I say that I don't want to do today. And they say that's fine – choose something else. And also they give you suggestions: Why don't you do this? Yes, or no sorry, pick something else. So thank you for that because that encourages and helps us continue" (PW5).

Providing a safe space to 'grow' as the third subtheme relates to the previous subtheme, but it focusses more on psychological aspects relating to safety rather than the practicalities concerned with easy and safe gardening. Several participants highlighted how much it meant to them that they knew that fall-prevention professionals were watching them and instructing them how they could garden safely: "They provide the safeguards to make sure that nothing happens to us really" (PT6). Furthermore, the fact that there were often almost as many support staff members as there were participants meant that support was always available. These points seemed to help the participants, who otherwise reported that low confidence levels limited them in their activities, to engage in activities notwithstanding their fear of falling.

Positive effects of participation

Participants reported that they experienced various positive effects due to engaging in the gardening programme, which we summarised in three subthemes. Firstly, various *Improvements of mental and physical wellbeing* were highlighted. Participants for instance reported to feel healthier, satisfied, less fearful of falling, more confident, more purposeful, and more relaxed. For example: "Physically, it [gardening] helps you to mobilise and it helps you to be active and you know improve the wellbeing. I think that's a very, very important aspect" (PW5). "I used to have a fear of losing a sense of balance that has improved a lot. You could do it from various exercise, but this kind of project seems to have much improved the fear of falling. That has contributed a lot" (PW4).

Another subtheme was to *Having a goal and reason to go out*. This non-gardening specific aspect was reflected in various statements regarding the importance of engaging in a regular activity which gives one's day structure and a purpose: "And having to come out. A goal. Having to come out to meet people" (PT2). Just the fact that participants needed and wanted to go somewhere lead to an increase of their activity levels, as this quote shows: "Oh, it [participating in the programme] has given me discipline to, you know, focus on the day that I do it. Usually when I get back I want to carry on doing some gardening in my own garden. So it keeps it going. But, you know you're going to meet people who are doing the same thing as you, like minded and all that. You have to get up and keep to a timetable, which is not a bad thing and gives one a bit of focus" (PW6).

Exercise becomes more meaningful was identified as the last subtheme. Participants reported that by partaking in the gardening programme they started to appreciate other exercises they had learned in standard fall-prevention exercise classes more. They saw these exercises as a building block for gardening. By actually using certain gardening movements, they understood why it was important to practise it (see quote below). Some participants also said they realised that it is good to have a small warming up routine before engaging in physical activities, as was done before each gardening session.

> Participant W3: I think exercise, if you look back on the exercise, it ties in with the gardening. All the things that we did in the exercise, you suddenly realise, ah yes that's why we did that. Especially… [does a certain exercise movement].
>
> All: Oh yes [laughter].
>
> Participant W3: Coming to the gardening you need it.

Discussion

The current study investigated the effectiveness and feasibility of a group-based, intergenerational fall-prevention gardening programme. This was done by gathering and analysing quantitative as well as qualitative data. Statistical examination of the quantitative data showed no significant changes from T1 to T2 for the primary (physical mobility, health, wellbeing, and fall efficacy levels) or secondary (general self-efficacy and social connectedness) outcome measures. However, the current fear of falling and the confidence to achieve goals showed significant moderate to large improvements after the intervention in the exploratory analyses. The descriptive analysis of health, with the exception of the anxiety/depression dimension, and activity levels indicated that more participants experienced positive changes than negative or no changes. Furthermore, the qualitative analysis of participants' subjective experiences highlighted that they gained a variety of benefits related to the gardening programme and that is was a successful programme for them.

Effects of the programme

When solely considering the null hypothesis testing results of the study, there is only little support for the ability of the programme to improve physical and psychosocial health measures, since no statistical differences were found for any of the quantitative primary and secondary outcome variables. Only the exploratory analyses revealed significant reductions in the participants' fear of falling, and a significant increase in their confidence to achieve goals. These findings can partly be explained by the small number of participants the programme was able to accommodate due to practical and health and safety reasons. This means the study was underpowered. Differences from T1 to T2 might have not been statistically significant, even though variations were present, as indicated by medium effect sizes for many outcome variables (Visentin et al. 2020). This assumption is also supported when looking at the findings by Siegrist and colleagues (2016) who conducted a larger RCT with about 200 participants in their exercise group. They found similar – and in their case significant – improvements (0.9 seconds) for the Timed Up and Go Test, as did we (0.8 seconds). However, in contrast to our results, participants of this larger RCT also reported a significantly lower fear of falling after the intervention using the FES-I, with a change from 25.2 to 23.4 points. Noteworthily, their participants' fear levels were lower than the levels of our participants by an average of 29.5 points.

In line with Lambdin's (2012) warning about drawing premature conclusions based only on significance testing and the practical significance of results (Lakens 2013), we do thus not conclude that the gardening intervention had no effects. We also come to this conclusion because of the qualitative findings of this study, since one of the themes identified in the thematic analysis describes the positive effects participants experienced due to their participation in the programme. In line with the effects known to be linked to engagement in gardening activities (Van Den Berg and Custers 2011; Wood et al. 2016), participants reported a multitude of positive states and feelings, and various improvements in mental and physical wellbeing and health outcomes. A majority of the participants furthermore reported that their participation in the gardening intervention either increased their activity levels or influenced it positively in another way, such as by being more focused when walking. Participants also verbally described what had been reflected in the quantitative data, namely that participation in the programme had positively impacted their confidence and reduced their fear of falling. Another important positive effect, which seems to have received hardly any attention in previous studies, is that participants stated the programme gave them a goal and a reason to go out. Just leaving the house at all will often be beneficial regarding clients' activity levels and social contacts, especially for more vulnerable individuals who might suffer from anxieties or loneliness (Cohen-Mansfield et al. 2016). It is likely that this effect will occur in particular when programmes are very motiving, like the gardening sessions, of which most participants

did not want to miss even one. Another positive effect of participating in the gardening intervention was the better understanding and acknowledgement of the other exercise classes participants engaged in. It is important to highlight that participants did not report disliking standard exercise classes, and that some even preferred their higher intensity levels. However, these classes often remained abstract, and the gardening programme, which also included warming up and cooling down sessions, made them realise why they had learned certain exercises. The movements became more meaningful and more relevant for their daily life.

In addition to these findings relating to the participants' subjective experience, it is also key to pay attention to adherence to interventions when examining the effects of a programme. As Nyman and Victor (2012, p. 17) highlighted: "Regardless of how efficacious an intervention may be, it will have poor effectiveness if older people either decline to participate or do not adhere to the intervention protocol". In the current study, all participants completed all eight gardening sessions and none of them dropped out. Even though the sample was small and the intervention time not very long, this indicates that the programme was very effective in successfully engaging the participants. The participants' ratings of their wish to continue with the programme also clearly support this point. Unfortunately, it was not possible to monitor the recruitment success, since in combination with the strict criterion that participation in the programme should not affect standard clinical care, our findings cannot provide any information on whether participants were more likely to accept an invitation to a gardening fall-prevention group.

Key pillars of the programme

In addition to insights regarding the effects of a gardening programme, our findings also help to understand *why* the programme was so successful in keeping participants engaged. Knowing about these factors is key for increasing acceptability and adherence to programmes (Bunn et al., 2008). Thematic analysis of the participants' experiences revealed what factors facilitated participation in the programme. While two of the factors we found (*Positive group interaction*, *Enjoyment*) overlap strongly with the facilitators Bunn and colleagues (2008) identified ("Emphasis on social aspects of interventions", "Making exercise fun/enjoyable/sociable"), we also found three other important factors: *Feelings of achievement*, *Body and mind*, and *Aesthetic and natural experiences*. All three factors seem to be unique to the gardening setting, as standard exercise settings do not provide the possibility to see one's own achievement, to learn about gardening, and to be outside and perceive colour, taste, smell, and the touch of plants and their products. Taken together, these five factors highlight that older adults do not only want to train physical strength and abilities. Participants in our study liked and wanted to learn applicable, and practical gardening and movement knowledge, meet and interact with others, enjoy themselves, see what they achieved, be in touch with nature, use cognitive skills, and stimulate their mind. Cognitive and mental stimulation can also be promoted in different ways in fall-prevention programmes, for instance by means of obstacle avoidance task mimicking activities of daily life and additional cognitive tasks (Weerdesteyn et al. 2006). Yet these methods still lack many of the other identified motivating factors.

Participants furthermore highlighted that it was very important for them that their special needs, strengths, and limitations were considered, that there was thoughtful preparation of the gardening site and the gardening session, and enough support staff members and fall-prevention experts to feel safe. Bunn and colleagues (2008) also identified several facilitators which relate to this point, such as personalised modifications, good leadership/facilitation, and programmes tailored to needs or lifestyle. We listed the *Special needs of the target group* as specific theme and factor which needs to be considered, and not just as part of the motivational facets,

as it seems to be a fundamental pillar of the gardening programme's success. All in all, our results show that a gardening programme constitutes multiple and partly unique motivating factors which could increase intervention adherence and thus also the effectiveness of a programme (Nyman and Victor 2012).

Feasibility and sustainability of the programme

Since no fall-prevention gardening intervention programmes have been scientifically evaluated and described to date, this study provides important insights into the feasibility of such a programme (Chen and Janke 2012). When examining the practicalities of the programme, it becomes quickly apparent that running such a programme requires a lot of preparation and a large number of supporting staff members. It also needs gardening material and equipment, and gardening expertise when designing the gardening site and the sessions for the first time. However, considering the personal and societal costs related to falling, clinical treatment, and possible further functional decline, the costs for such a gardening programme will probably still be lower (Pereira et al. 2008), especially when considering that such a programme could have lower dropout rates and reach clients who might otherwise decline to take part in any fall-prevention classes. Furthermore, no falls and only one near-miss occurred in the gardening groups. While falls related to an exercise intervention or study participation occurred in other studies too, many studies do not report near-misses, so it remains unclear whether participation in the gardening programme was riskier than participation in other exercise programmes (Weerdesteyn et al. 2006; Siegrist et al. 2016; Lamb et al. 2020). In the targeted population, falls can occur in any type of intervention which includes partially challenging activities. Thus, when appropriately prepared and supervised, the fall-prevention gardening programme seems to be a feasible alternative to traditional types of exercise and could surely at least complement conventional fall-prevention offers.

Considering the strong wish for a continuation of the programme we saw in participants, it would be advisable to run a regular, professionally supervised gardening group, as is also sometimes seen in hospitals or nursing homes (Raske 2010). However, it must be taken into consideration that safety is an important concern, and the provision of professional support is key. The inability to ensure such professional support on the gardening site after the funding period for the current project ended unfortunately also meant that the groups were not continued, as originally hoped for. For the university the risk of adverse events was too high and the IFBHS no longer had the capacity to supervise the sessions at an external location. The gardening site continued to be used by the university's "[*name deleted for review*]" team as a location for growing sustainable produce, but attempts to open up the space for clinical groups did not succeed. By teaching the participants how they could garden safely and comfortably, they were however empowered to also engage in gardening activities at home. This can be seen as a contribution to the sustainability of such an intervention, yet, it needs to be highlighted that not all people have access to gardens. Ideally, everybody should have access to a garden which is suitable for the target group and publicly available, but unfortunately the current project did not succeed in creating such a space in a sustainable way (Buck 2016).

Strengths and limitations

The current study is the first clinical trial testing the effects of a gardening intervention. All in all, the findings provide promising evidence for positive effects of the intervention and for the feasibility of a fall-prevention gardening programme. Our findings highlight the unique chances a gardening programme can offer, including high attractiveness for a diverse target group, stimulation of positive physical, social, cognitive, and affective states, and the empowerment of participants. By using a mixed-methods approach, we were able to provide useful and detailed insights for professionals who want to implement a gardening group for an older

adult population in general, and in particular older adults at risk of falling.

However, the current findings need to be interpreted in light of the study's limitations. The biggest limitation of the current study was the small number of participants. We aimed at 30 participants, but realised that we could not accommodate more than 16. Therefore, our study was underpowered and we were not able to draw robust statistical conclusions. Furthermore, due to ethical and resource-related limitations, the current study did not use a control group and there was no long-term fall assessment. We cannot therefore draw conclusions regarding the effectiveness for the prevention of falls, and the effects we found could in theory also be the result of general treatment effects. Making use of long-term assessment, including a control group and randomisation in the future, would therefore significantly advance the current evidence, although the qualitative findings of our study do imply that the effects of the intervention were closely linked to the actual gardening activities, and not just to general intervention effects. It is also an important limitation of the study that not every older adult at risk of falling was eligible to participate. Eligible participants were those able to mobilise without walking aids, with no known diagnosis of dementia, and who had already completed standard fall-prevention classes, were awaiting participation in these classes, or had rejected invitations to such classes. This was done so as to not affect any existing standard clinical care. Our findings can thus not be generalised to all older adults at risk of falling. Lastly, the study does not provide insights into acceptance rates for a gardening fall-prevention programme.

Conclusion

Overall, a gardening programme seems to be a promising fall-prevention intervention for older adults at risk of falling, but who can move freely on a gardening site designed for this target group. The intervention programme was perceived very positively by all involved parties, namely participants, student volunteers, and staff members, and participants reported various positive changes. However, future studies need to further investigate the effectiveness of the programme, ideally using an RCT design and larger sample sizes. Apart from the study's relevance regarding gardening interventions, our findings highlight factors which could be systematically targeted to further increase participants' motivation, acceptance, and adherence rates to fall-prevention programmes (Bunn et al., 2008). It seems to be advisable for programme makers to pay more attention to the identified factors, such as by allowing more space for interpersonal exchange, or instigating physical as well as mental training and learning. The findings of our study imply that participants appreciate a purposeful and more holistic programme which gives them a sense of achievement, which has social, cognitive, and perceptual facets, and which also stimulates their physical capabilities.

Declarations

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Conflicts of interest/Competing interests: The authors have no relevant financial or non-financial interests to disclose.

Ethics approval: This study was performed in line with the principles of the Declaration of Helsinki. The study received approval by the Health Research Authority (HRA; NHS England) and the HRA Research Ethics Committee (REC reference number: *[removed for review]*).

Consent to participate: Informed consent was obtained from all individual participants included in the study.

Consent for publication: NA

Availability of data and material (data transparency): Questionnaire items and quantitative raw data without any personal information are available via the OSF ([link removed for review]). Detailed intervention material can be found in the Supplementary online material.

Code availability (software application or custom code): NA

Author contributions: All authors contributed to the study conception, the study design, and the implementation of the intervention. All authors contributed to material preparation, and data collection. The funding acquisition, ethical approval procedure, and the overall execution of the project was led by *[removed for review]*. *[removed for review]* headed the participant recruitment, created the intervention content, and led all intervention sessions. *[removed for review]* performed the data analysis and wrote the first draft of the manuscript. All authors contributed to the final version of the manuscript and read and approved the final manuscript.

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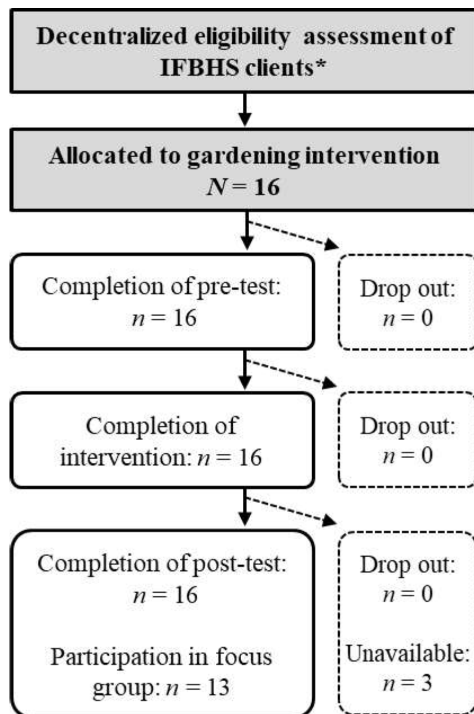
1 **Figure 1**

2 *Flow diagram documenting the flow of participants through the trial*



3

4 IFBHS = Integrated Falls and Bone Health Service

5 * Recruitment had to take place in the field and was conducted by staff members of the IFBHS team
6 as part of their daily work with and intake of clients. Due to the decentralised approach, we are
7 unable to provide reliable information regarding the number of clients who were screened and/or
8 assessed for eligibility.

1 **Figure 2**

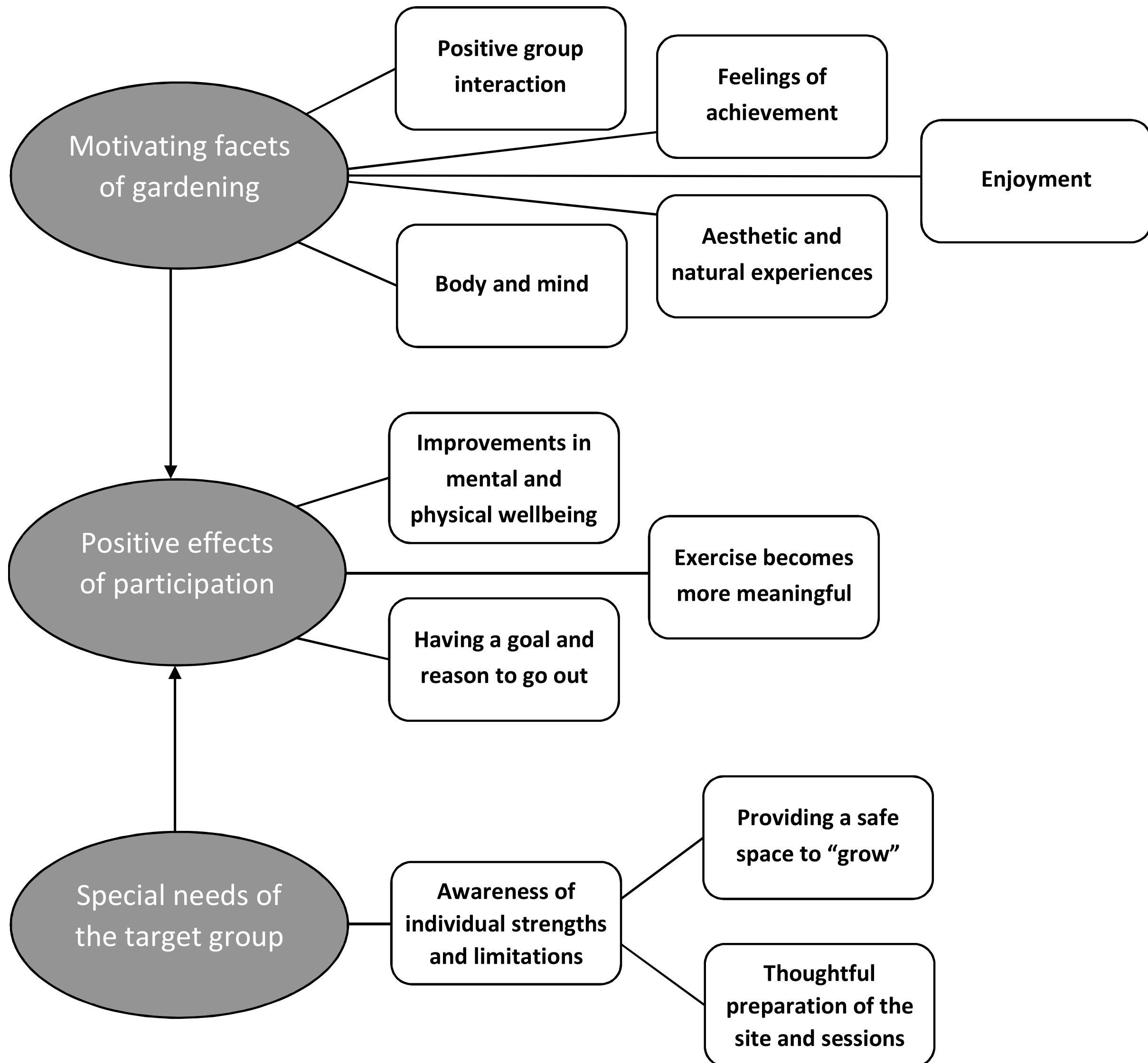
2 *Pictures of the gardening site at the University of [name deleted for review] campus before the*
3 *programme (February 2017, left picture) and after the programme (August 2017, right picture)*

4

5 Additional colour pictures can be found in Supplementary Figure 1.

1 **Figure 3**

2 *Themes (in grey) and subthemes (in white) identified in the thematic analysis*



3

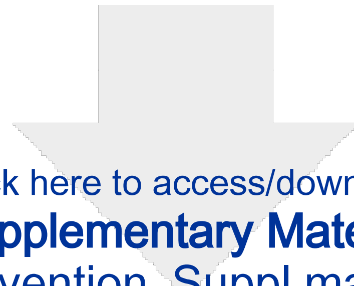
Table 1

Summary of the changes from pre- to post-measurement

		Before intervention Mean	*SD*	After intervention Mean	*SD*	*p* (two-tailed)	Effect size
Physical outcome measures	Up and go[a]	12.88 s	3.90	12.07 s	3.93	.282	d_z = -0.28
	Turn test	4.75 steps	1.06	4.31 steps	0.70	.156	*r* = -0.50
	Sit-to-Stand[a]	9.00 times	3.20	9.31 times	3.05	.552	d_z = -0.15
Health (EQ-5D index score)		0.78	0.14	0.82	0.15	.078	*r* = -0.34
Wellbeing[a] (WEMWBS)		3.90	0.76	4.08	0.79	.069	d_z = -0.49
Fall efficacy (FES-I[b])		29.59	9.21	29.44	9.34	.801	*r* = -0.05
General self-efficacy[a]		3.18	0.48	3.21	0.57	.762	d_z = -0.08
Social connectedness[c]		5.18	0.98	5.35	0.81	.320	*r* = -0.25
Fear of falling[a]		4.00	2.00	3.38	2.47	**.028**	d_z = 0.61
Confidence goal achievement		7.25	1.51	8.47	1.54	**.005**	*r* = -0.53

Note: The white, grey, and dark grey part of table reflect the primary, secondary, and exploratory outcome measures respectively; WEMWBS = Warwick-Edinburgh Mental Wellbeing Scale, FES-I = Falls Efficacy Scale-International, *SD* = standard deviation, s = seconds; *p*-values below the significance level of .05 are highlighted by bold print; effect size calculation as in Lakens (2013) and Field (2018)

[a] T-tests were used for analysis; all other variables were analysed using Wilcoxon signed rank test; [b] Values above 28 were classified as high concerns for falling; [c] *n* = 14 due to missing values



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