Valéria Farkas, András Simon, Izabella J. Sztruhár, Zsigmond Gyombolai and Éva Kovács*

# Effect of horticultural therapy on static, dynamic balance and gait speed among institutionalized older adults with cognitive impairment

https://doi.org/10.1515/jcim-2024-0100
Received March 28, 2024; accepted July 15, 2024;
published online August 8, 2024

**Abstract**

**Objectives:** Although horticultural therapy has been used successfully to reduce neuropsychiatric symptoms in elderly people with cognitive impairment, we do not yet know how it affects balance. The aim of our study was to determine the acceptability and effect of a 12-week horticultural therapy on balance and walking speed among institutionalized older adults with cognitive impairment.
**Methods:** This mixed-methods controlled trial included 23 participants. Subjects in the experimental group (n=13) participated in a 60 min horticultural therapy programme twice a week for 12 weeks in addition to the institution's usual social activities. Subjects in the control group (n=10) participated in the institution's usual social activities. Static and dynamic balance were measured with the Performance Oriented Mobility Assessment scale. In addition, gait speed was measured. Qualitative data were collected through a semi-structured interview with participants of the experimental group.
**Results:** At the end of the intervention period, the experimental maintained their baseline performance on the static balance, while the control group showed a decline. The gait speed of the experimental improved, while that of the control group did not change. In dynamic balance, no changes were demonstrated. The results of our qualitative data analysis indicate that horticultural therapy increases the possibility of social interactions, encourages older people to engage in conversation.
**Conclusions:** As a conclusion, horticultural therapy should be more widely included in programmes for older people with cognitive impairment.

**Keywords:** horticultural therapy; balance; gait speed; older people; cognitive impairment

## Introduction

Dementia and cognitive impairment (CI) are chronic syndromes caused by several diseases. The symptoms lead to a decline in self-care through a loss of higher intellectual functioning, behavioral and psychological symptoms as well as somatic dysfunction [1]. According to international data, the prevalence of dementia is 1.5 % at the age of 65 and could increase to 30 % by the age of 90 [2]. Due to the prevalence of dementia and its impact on several areas of life, there is a growing emphasis on alleviating the symptoms and addressing the problems associated with dementia and CI in elderly care worldwide [3–5]. Growing body of studies have researched and partially proven that non-pharmacological therapies, including horticultural therapy (HCT) can be successfully applied to this difficult task [6–13].

HCT is the therapeutic use of plants or garden care activities, under the guidance of a trained professional, for clinically defined purposes [14]. Gardening was already used by doctors in medicine in ancient and medieval times, and it became widespread as a rehabilitation tool during and after World War II [15]. The first scientific evidence comes from a study that was published in a US peer-reviewed journal, in 1979 [16]. Since then, numerous studies have demonstrated that the multifaceted effects of HCT improve cognitive, psychological, social and somatic functions in older people with CI [8, 17, 18].

***Corresponding author: Éva Kovács PhD**, Faculty of Health Sciences, Department of Morphology and Physiology, Semmelweis University, Budapest, 17 Vas street, H 1088 Hungary,
E-mail: kovacs.eva@semmelweis.hu
**Valéria Farkas,** Faculty of Health Sciences, Department of Nursing, Semmelweis University, Budapest, Hungary,
E-mail: farkas.valeria.hn@gmail.com
**András Simon,** School of PhD Studies, Semmelweis University, Budapest, Hungary; and Faculty of Health Sciences, Department of Physiotherapy, Semmelweis University, Budapest, Hungary, E-mail: simandras@gmail.com
**Izabella J. Sztruhár,** Faculty of Health Sciences, Department of Physiotherapy, Semmelweis University, Budapest, Hungary; and Old Age Home of the Municipality of Budapest, Budapest, Hungary,
E-mail: fizioterapia@gmail.com
**Zsigmond Gyombolai,** School of PhD Studies, Semmelweis University, Budapest, Hungary; and Faculty of Health Sciences, Department of Morphology and Physiology, Semmelweis University, Budapest, Hungary,
E-mail: gyozsiga@gmail.com

Several publications report the effective use of HCT as a non-pharmacological tool to reduce neuropsychiatric symptoms such as anxiety and depression [8, 17, 18].

Although a body of research has indicated that dementia is associated with a decline in balance [19–23], only one study has examined the effects of HCT on balance variables [24]. Chen and Janke's research [24] found that older adults defined as gardeners (those who had spent 1 h or more gardening in the week before the survey) had better balance and gait speed (GS) than older adults who were defined as non-gardeners. So far, this is the only research to suggest that HCT is a promising activity for improving balance and reducing falls among older people. However, we have no information on whether this effect is also seen among older people with CI. Since most of the research on HCT comes from Asia, the US, Australia and New Zealand, it is not known what the acceptability of HCT is in a region where there is no tradition of this type of therapy [25].

Therefore, the aim of our study was twofold. On one hand, the aim was to determine the effect of a 12-week HCT on static and dynamic balance, and GS among institutionalized older adults living with CI. The potential effects of the HCT beyond balance and GS were explored by a qualitative assessment. On the other hand, our research aimed to reveal the acceptability of such therapy among this population.

# Methods

This study was designed using mixed methods, which consisted of a prospective controlled trial and semi-structured interviews.

## Study sample

The study was conducted with cognitively impaired participants in a long-term care institution in Budapest, Hungary from March 2021 to November 2021.

First, the 480 residents were screened for CI with Mini-Mental-State-Examination (MMSE) test [26]. For this test, the maximal possible score was 30. A score below 24 was considered as CI [27].

A total of 234 older individuals with CI were contacted to be included in this study. Subjects were excluded if they had lived in the nursing home for less than 2 months, were younger than 60 years of age, were unable to walk at least 6 m with or without walking aid, had an MMSE score below 10 points, were in a terminal state, or planned to move from the nursing home during the study period. The enrolment procedure took 10 days.

Subjects and their guardians were informed orally and in writing of the purpose, procedure, and measures of the study and their right to withdraw from the study at any time. Written informed consent was obtained from participants or their guardians. A total of 23 people were selected for the study. They were divided into two groups according to their proximity to the place of the HCT sessions. The experimental group (EG) (n=13) consisted of those who lived in a unit with a garden specifically designed for this research. Those in a similar condition but living in a different unit formed the control group (CG) (n=10).

## Intervention

Besides the institution's usual social activities (reminiscence therapy and handicraft activities), EG subjects participated in a 60 min HCT programme twice a week for 12 weeks. When choosing the location of the therapy sessions, one of our primary considerations was the safety of the participants. The area for therapy sessions was fully barrier-free, with ramps provided for those using wheelchairs for longer distances, including access to the garden. Handrails and grabs were installed along the barrier-free walkway. The area was surrounded by a lockable fence. The raised beds were previously set up under shade trees. Benches were placed between the raised beds to provide a resting place during the 60 min sessions of gardening.

The programme included the well-known gardening steps, such as preparing the beds, planting the seedlings, weeding, trimming, watering and harvesting. One of the raised beds contained seedlings of herbs and herbaceous plants, the other seedlings of annual garden flowers, and the third seedlings of tomatoes. While gardening, elderly persons indirectly practiced balance position changes frequent in activities of daily living through multidirectional stepping, weight transfer, and variable base of support.

No scheduled rest breaks were provided, but each participant was allowed to rest according to their individual needs. According to the protocol, if we saw that someone was resting too much, we would motivate them and involve them in sub-activities. But this was not necessary because everyone was actively participating.

CG members participated only in the institution's usual social activities.

## Data collection

### Quantitative

At baseline, the following data were collected from the nursing documentation: sociodemographic data (age, gender), physical and medical characteristics (weight, height and calculated BMI, and chronic diseases).

The outcome variables were: static and dynamic balance, as well as GS.

The static and dynamic balance were measured by the Performance Oriented Mobility Assessment (POMA) scale. This POMA scale consisted of two parts: balance scale (POMA-B) measuring the static balance and gait scale (POMA-G) measuring the dynamic balance [28]. The balance-related items scored the sitting balance, rising from a chair and sitting down, standing balance (with eyes open then closed) and turning balance. The gait-related items scored gait initiation, step length, height, symmetry and continuity, as well as path direction and trunk sway. Each item was scored based on a 2- or 3-point scale. Balance and gait elements were scored and analyzed separately. A maximum score of 16 on POMA-B, a maximum score of 12 on POMA-G could be achieved. The tests' interrater reliability is good (85 % agreement) [29].

GS was measured by asking subjects to walk at their usual pace on a flat 14 m track, starting from a standing position. The walking path included an initial distance of 2 m for acceleration and an ending distance of 2 m for deceleration, which were not included when determining GS. Use of a walking aid was permitted. The test was taken twice, and the mean of the two was used to calculate GS. To determine GS (in m/s), the 10 m distance covered was divided by the time needed for the subject to walk that distance [30]. GS is a valid measure of gait limitation with high predictive validity for subsequent disability, hospitalization and mortality [31].

Acceptability of the HCT programme was evaluated by the participants' adherence rate, the number of sessions completed, and the number of adverse events (falling or other medical events). Fall was defined as an "unexpected event in which the participants come to rest on the ground, floor, or lower level" [32].

### Qualitative

Qualitative data were collected through individual semi-structured interviews with six caregivers who were asked about their experiences of changes in older people's behavior.

The interviews were conducted 7–10 days after the end of the intervention. The caregiver informants were recruited from among the care professionals of the long-term care institution where the intervention was carried out.

Purposive sampling was used to ensure that professionals with different qualifications were interviewed. One geriatrician, two nurses, two care workers, and one mental health worker were invited to participate. All informants were women.

The interviews were conducted by the institution's psychologist, who was not involved in the intervention. The interviews included mainly open-ended questions focusing on the positive/negative changes in the older people's behavior. The informants were encouraged to provide details on their experiences. The interviews, which lasted about 20–25 min, were recorded with the informants' consent and transcribed verbatim.

## Data analyses

### Quantitative

First, the distributions of continuous data were checked using Kolmogorov–Smirnov test.

Participants' demographic and clinical characteristics were analyzed using descriptive statistics.

Baseline values of EG and CG were compared using independent-sample t-tests for continuous data and $\chi^2$ test for categorical data.

Mann–Whitney U-tests were conducted to determine whether there were statistically significant differences between groups in the outcome variables post-intervention. Within-group differences between baseline and post-intervention groups were investigated by Wilcoxon-tests.

The adherence rate of participants was calculated by dividing the number of completed sessions by the number of required sessions. Effects were analyzed on an intention-to-treat basis. This means that all available data were analyzed, and no participants were excluded if they failed to attend sessions.

Kovács et al. [33] reported a 4-point difference in POMA-G scores in older people with dementia after a multimodal exercise programme. On this basis, they determined that the number of subjects required for a significance level of alpha=0.05 and a power of 80 % was nine in each group. This was increased to 13 per group in the case of subjects withdrawing from the study and any potential missing data.

For the statistical analysis we used SPSS version 19.0 for Windows software. A p-value less than 0.05 was considered statistically significant.

### Qualitative

Three researchers analyzed the semi-structured interviews using thematic analysis.

In accordance with the adopted methodological procedure, data analysis involved the following phases: (1) familiarization with the data, (2) generation of initial codes, (3) theme search, (4) theme review, (5) theme definition, and (6) report production [34]. All three researchers read the interviews transcribed verbatim repeatedly to familiarize themselves with the data (step 1). Then, initial codes were generated (step 2), and the codes were grouped into subcategories to determine potential themes (step 3). Finally, reviewing, defining, and naming themes resulted in four main themes (step 4, 5 and 6). Illustrative quotes for each category were selected by the last author and translated from Hungarian to English by a native English speaker. The translations were approved by all authors.

**Table 1:** Demographic and clinical characteristics of study participants.

| Participants' characteristics | Experimental group (EG) (n=13) | Control group (CG) (n=10) | p-Value |
|---|---|---|---|
| Age (years), mean (SD[a]) | 78.7 (7.1) | 78.4 (8.1) | 0.910 |
| Female, number, % | 8 (62) | 9 (90) | 0.123 |
| BMI (kg/m$^2$), mean (SD) | 26.1 (5.6) | 23.9 (5.9) | 0.315 |
| MMSE[b] (points), mean (SD) | 16.1 (2.5) | 15.6 (3.1) | 0.429 |
| Katz index | 3.4 (1.04) | 4 (1.21) | 0.09 |
| Chronic diseases | | | |
| Diabetes mellitus, number, % | 4 (31) | 4 (40) | 0.645 |
| Hypertension, n, % | 10 (77) | 9 (90) | 0.169 |
| Lower limb arthritis, n, % | 7 (54) | 4 (40) | 0.510 |
| Osteoporosis, n, % | 6 (46) | 6 (60) | 0.510 |

[a]SD, Standard Deviation. [b]MMSE, Mini Mental State Examination.

# Results

## Quantitative findings

In the EG, all 13 participants who started the HCT programme completed the study. Six participants attended all sessions, two participants missed only one session, three missed two sessions and two missed three sessions. In the CG, three participants died from chronic illness. The cause of their death was not associated with the programme. The outcome values of these dropped-out participants were replaced with their baseline values. There were no other adverse events.

Adherence was calculated as the percentage of the number of sessions completed out of the total 24 sessions. Adherence to the exercise programme was 95.5 % with a range from 88 to 100 %.

Table 1 shows demographic and clinical characteristics of study participants. There were no significant differences between groups on any baseline characteristics.

The outcome data are presented in Table 2.

The EG showed a non-significant improvement in POMA-B (z=−1.652; p=0.098), while the CG showed a decline (z=−2.032; p=0.042). After the 12-week intervention period, there was a statistically significant difference between the EG and CG in POMA-B (U=22.5; p=0.008).

As for POMA-G, although the EG improved (z=−1.518; p=0.129) and the CG declined (z=−1.095; p=0.273), either change failed to meet the level of statistical significance. After the 12-week intervention period, the between group difference was not significant for POMA-G (U=38.5; p=0.094).

As for GS, there was a statistically significant improvement in the EG (z=−2.062; p=0.039), while there was no change in the CG (z=−1.014; p=0.310). After the 12-week intervention period, the between group difference was not significant for GS (U=42; p=0.154).

**Table 2:** Static and dynamic balance as well as gait speed at baseline and after the intervention periods in groups.

| | Experimental group (EG) | | Control group (CG) | |
|---|---|---|---|---|
| | At baseline | At 12 weeks | At baseline | At 12 weeks |
| POMA-B (point) median (IQR[a]) | 13 (12–13.5) | 14 (12–15) | 12 (7.5–15.25) | 10 (7.5–12.5) |
| p value[b] | | 0.098 | | 0.042 |
| POMA-G (point) median (IQR[a]) | 10 (9–12) | 11 (10–12) | 11 (6.75–12) | 8.5 (6.75–11.25) |
| p value[b] | | 0.129 | | 0.273 |
| Gait speed (m/s) median (IQR[a]) | 0.44 (0.35–0.53) | 0.58 (0.41–0.67) | 0.43 (0.31–0.61) | 0.44 (0.28–0.54) |
| p value[b] | | 0.039 | | 0.310 |

[a]IQR, Interquartile Range. [b]Within-group difference.

**Table 3:** Informants' characteristics.

| Informants | Age, years | Work experience in geriatrics, years |
|---|---|---|
| Geriatrician | 63 | 35 |
| Nurse 1 | 40 | 20 |
| Nurse 2 | 33 | 5 |
| Care worker 1 | 58 | 27 |
| Care worker 2 | 49 | 18 |
| Mental health worker | 38 | 9 |

## Qualitative findings

Informants' characteristics are presented in Table 3.

The following four themes were identified from the data:
Theme 1: Changes in social interactions
Theme 2: Changes in physical activity
Theme 3: Changes in participation in community activities
Theme 4: Reduced aggression in verbal communication.

Examples of representative quotations are provided in Table 4. In the quotations, patients' names have been replaced with fictitious names.

### Theme 1: Changes in social interactions

Informants clearly observed that participants in HCT interact socially with more of their residents. Several informants noted that after the garden sessions, conversations among the participants were more frequent even during periods outside the HCT. It was also observed that they initiated conversations not only with the participants of the session, but also with others.

The quality of family relationships has also changed in a positive direction. Participants tell visiting relatives about their gardening activities and show them their garden. Participants are proud of what they have done. In rural Hungary, it is still a traditional part of hospitality that the host shows his guests the garden he has cultivated. This experience also suggests that participants no longer consider

**Table 4:** Illustrative quotations for the four themes.

| Themes | Quotations examples |
|---|---|
| 1. Changes in social interactions | *„I have seen Maria, who used to prefer to sit mostly alone, chatting with her fellow patients on several occasions."* (observation of a 33-year-old nurse on a 69-year-old woman)<br>*"Katalin could not be included in a conversation. She did not even answer simple questions. (e.g. What is your name? How many children do you have?) During the program and since then, when asked, she lists what crops were grown in the sessions, what work was done."* (observation of a 40-year-old nurse on a 79-year-old woman)<br>*"Before, Pista had previously been completely withdrawn, not talking to anyone, not even the care staff. While gardening and after the gardening sessions, he started to talk about what he grew in his own garden."* (observation of a 38-year-old mental health worker on a 76-year-old man)<br>"*Lajos invites his visitors to the garden and is happy to walk around the garden with them, showing them the plants he has planted*." (observation of a 40-year-old nurse on a 77-year-old man) |
| 2. Changes in physical activity | "*Zsuzsa, who used to prefer to spend her days in her room, now often walks not only in the garden but also in the communal spaces*." (observation of a 49-year-old care worker on a 78-year-old woman)<br>*"I often see Zsuzsa sitting in the garden, but she also sits more often in an armchair in the lounge."* (observation of a 58-year-old care worker on a 78-year-old woman)<br>*„Rozália likes to go to the vegetable garden several times even beyond the sessions*<br>*Walking in the garden, Rozália watches the plants with interest. Sometimes she picks them up and is happy to give them to one of us."* (observation of a 58-year-old care worker on a 80-year-old woman) |
| 3. Changes in participation in community activities | *"Previously, Erzsi spent all her time in her room, except for personal hygiene and eating. After the garden therapy period, she was more involved in meal preparation activities, such as setting the table."* (observation of a 49-year-old care worker on a 66-year-old woman)<br>*"Maris, who had never before taken part in reminiscence therapy, told other residents a lot about her garden, which she used to cultivate."* (observation of a 38-year-old mental health worker on a 83-year-old woman)<br>*„Lili had not previously participated in group exercise sessions. After the garden therapy, she could be involved, with the promise of meeting her peers with whom she gardened."* (observation of a 38-year-old mental health worker on a 79-year-old woman) |
| 4. Reduced aggression in verbal communication | *„In the past, Pista was often irritable, impatient, and cursed. During and after the garden therapy program, cursing barely ever happens."* (observation of a 49-year-old care worker on a 76-year-old man) |

only their room but also the garden as their home environment.

#### Theme 2: Changes in physical activity

The informants also reported that the participants in the EG spend more time in the garden and in the raised beds, even during periods outside the sessions. Informants also found that older patients are more often seen not only in the garden but also in other community spaces.

#### Theme 3: Changes in participation in community activities

Informants found that older people who participated in HCT sessions were more easily involved in other community activities. HCT participants were also involved in several community activities in which they had not previously participated.

Several informants reported that older people in the EG who could not previously been involved in leisure activities, now occasionally took part in reminiscence therapy or animal-assisted therapy sessions.

According to informants, several residents appeared at irregular intervals in the garden with watering cans to water the plants. In order to prevent overwatering, a watering schedule had to be established, so that watering always took place at the scheduled time.

#### Theme 4: Reduced aggression in verbal communication

Informants reported reduced levels of aggression in patient-to-patient communication. The use of swear words, which were commonly heard otherwise, were barely observed during and after the therapy sessions.

## Discussion

This study was designed to evaluate the effects of a 12-week HCT programme on static and dynamic balance, as well as GS among institutionalized older adults living with CI.

At the end of the intervention period, the EG maintained their baseline performance on the static balance variable, while the CG showed a decline. In terms of GS, the EG improved while the CG did not change. However, no changes were demonstrated in dynamic balance.

Our data showing significant change were compared with MDC values reported in the literature. Regarding POMA balance score, improvement of six individuals in the EG while a decline of five individuals in the CG exceeded the published MDC for older people with knee osteoarthritis (MDC=0.75) [35]. Regarding GS, improvement of eight individuals of the EG were above the corresponding value for individuals with CI (MDC=0.11 m/s) [36].

So far, multidimensional exercise programmes (MDEP) and senior dance have been demonstrated to be beneficial for the balance and gait of cognitively impaired older people.

The MCEPs with beneficial effects, besides aerobic exercises, included balance [37, 38] and/or strengthening [39, 40] and/or flexibility [39, 41] exercises. Similarly, the High Intensity Functional Exercises programme (Umeå, Sweden), being also beneficial for the balance of older people with CI, applies progressively higher intensity muscle strengthening as well as “sufficiently challenging” balance exercises [42–44]. Two meta-analyses demonstrate the beneficial effects of senior dance on static and dynamic balance in older people with dementia [45, 46].

The studies mentioned above suggest that balance variables of even older people with dementia can be improved. The results of our study indicate that HCT is just as effective as the interventions mentioned above for this purpose.

However, research also shows that people with dementia find it difficult to engage in leisure or specifically therapeutic activities [47]. Therefore, it is important that professionals caring for older people with dementia/CI are equipped with as many effective interventions as possible to develop the balance skills essential for effective and safe movement. HCT is one of the interventions that has been used successfully not only in people with intact cognitive function but also in people with CI.

As for psychosocial effects of HCT, researches demonstrate that HCT reduces stress levels, stimulates memory, improves attention, helps to acquire new knowledge and skills, recalls and stimulates existing skills, reduces the frequency of behavioral disorders, enriches social interactions, and helps to experience a sense of usefulness and responsibility [6, 7, 48]. These effects of HCT are supported by results based on qualitative data from our research. The results of our qualitative data analysis indicate that HCT increases the possibility of social interactions, encourages older people to engage in conversation. Not only have the interactions between the older people participating in the HCT programme been enriched, but also their interactions with other residents. More older people became involved in various activities of community life. Participants in the HCT sessions were more easily involved in other community activities provided by the institution. People have also been involved in reminiscence sessions or animal-assisted therapy sessions who could not previously have been involved in these types of activity. This observation could possibly be explained by the fact that they sought the contact of those

with whom they had formed a good relationship during HCT sessions. Future research should consider participation in community activities as an outcome variable.

Jing (2016) suggests that daily physical activity is a major determinant of quality of life (QoL) in institutionalized older people with dementia and is negatively associated with physical aggressive behavior [49]. Telenius (2013) hypothesized a relationship between QoL and walking speed in this population [50].

HCT we studied provides daily physical activity and also reduces aggressive behavior, while having a positive effect on balance variables, especially walking speed. Therefore, the unique result of our study is that HCT, besides reducing physical aggressive behavior, improving GS, and helping to maintain static balance (by slowing its decline), is thought to contribute to a better QoL for older people with CI living in nursing homes.

As for acceptability of HCT, all members of the EG completed the intervention period. Some attended all the sessions prescribed, but even the least adherent participant attended more than four-fifths of the sessions. This suggests that HCT is also an accepted activity for the Hungarian older people with CI, for whom there has been no tradition of this therapy so far.

Some limitations of this study should be mentioned. First, participants were not randomly assigned to groups. We did not want to exclude potential participants from intervention research that has been shown to have beneficial effects on behavioral symptoms in older patients. The other limitation of this study was the lack of blind assessment. The inclusion of blind assessment in future studies is therefore heavily recommended. Finally, in our study, all participants were recruited from a long-care institution. Thus, older adults receiving day-care or homecare are not represented in our sample. Therefore, generalization should be made with caution. Despite these limitations, our research indicates that HCT has positive effects not only on cognitive and mental symptoms but also on balance variables. Thus, this is another therapeutic option that can be added to the range of programmes for people with dementia/CI.

The professional responsible for the care of older people can choose from this range of programmes according to the personal and material conditions of the institution and the older person's preferences.

## Conclusions

Professionals working with older people with dementia/CI have the responsibility of planning, organizing, and implementing daily activities that offer so-called non-pharmacological therapy. It is a great challenge to design a programme for older people with CI that not only provides meaningful leisure activities, but also has a positive impact on the physical and mental health of the older person, including the balance as well, that is the basis of daily life. Adding the results of our study to the body of research to date, it can be concluded that many programmes, including HCT, can be used effectively to improve balance variables even in older people with CI. The more effective programmes are known, the easier it is to involve the older person with CI in a programme that they can enjoy in the long-term, improving their physical and mental health and thus their QoL.

**Acknowledgments:** The authors would like to thank Richardné Mayer for her help in conducting individual semi-structured interviews and thematic analysis.

**Research ethics:** This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Institutional Review Board (AP05/12-1/2021).

**Informed consent:** Informed consent was obtained from all individuals included in this study, or their legal guardians or wards.

**Author contributions:** The authors have accepted responsibility for the entire content of this manuscript and approved its submission.

**Competing interests:** Authors state no conflict of interest.

**Research funding:** None declared.

**Data availability:** The raw data can be obtained on request from the corresponding author.

## References

1. Gale SA, Acar D, Daffner KR. Dementia. Am J Med [Internet] 2018;131:1161–9.
2. Ferri CP, Prince M, Brayne C, Brodaty H, Fratiglioni L, Ganguli M, et al. Global prevalence of dementia: a Delphi consensus study. Lancet [Internet] 2005;366:2112–7.
3. Khoo YJ-L, van Schaik P, McKenna J. The Happy Antics programme: holistic exercise for people with dementia. J Bodyw Mov Ther [Internet] 2014;18:553–8.
4. Abraha I, Rimland JM, Trotta FM, Dell'Aquila G, Cruz-Jentoft A, Petrovic M, et al. Systematic review of systematic reviews of non-pharmacological interventions to treat behavioural disturbances in older patients with dementia. The SENATOR-OnTop series. BMJ Open [Internet] 2017;7:e012759.
5. Vilela VC, Pacheco RL, Latorraca COC, Pachito DV, Riera R. What do Cochrane systematic reviews say about non-pharmacological interventions for treating cognitive decline and dementia? Sao Paulo Med J [Internet] 2017;135:309–20.

6. Edwards CA, McDonnell C, Merl H. An evaluation of a therapeutic garden's influence on the quality of life of aged care residents with dementia. Dementia [Internet] 2013;12:494–510.
7. Gonzalez MT, Kirkevold M. Benefits of sensory garden and horticultural activities in dementia care: a modified scoping review. J Clin Nurs [Internet] 2014;23:2698–715.
8. Blake M, Mitchell G. Horticultural therapy in dementia care: a literature review. Nurs Stand [Internet] 2016;30:41–7.
9. Lu L-C, Lan S-H, Hsieh Y-P, Yen Y-Y, Chen J-C, Lan S-J. Horticultural therapy in patients with dementia: a systematic review and meta-analysis. Am J Alzheimers Dis Other Demen [Internet] 2020;35: 153331751988349.
10. Bourdon E, Belmin J. Enriched gardens improve cognition and independence of nursing home residents with dementia: a pilot controlled trial. Alzheimers Res Ther [Internet] 2021;13:116.
11. Murroni V, Cavalli R, Basso A, Borella E, Meneghetti C, Melendugno A, et al. Effectiveness of therapeutic gardens for people with dementia: a systematic review. Int J Environ Res Public Health [Internet] 2021;18: 9595.
12. Velde-van Buuringen M van der, Hendriks-van der Sar R, Verbeek H, Achterberg WP, Caljouw MAA. The effect of garden use on quality of life and behavioral and psychological symptoms of dementia in people living with dementia in nursing homes: a systematic review. Front Psychiatry [Internet] 2023;14:1044271.
13. Wang M, Wu J, Yan H. The effect of horticultural therapy on older adults in pension institutions: a systematic review. Geriatr Nurs [Internet] 2023;51:25–32.
14. American Horticultural Therapy Association. American Horticultural Therapy Association (AHTA) definitions and positions paper. Ahta.org; 2017. Available from: https://www.ahta.org/assets/docs/definitions%20and%20positions%20final%206.17.pdf.
15. Detweiler MB, Sharma T, Detweiler JG, Murphy PF, Lane S, Carman J, et al. What is the evidence to support the use of therapeutic gardens for the elderly? Psychiatry Investig [Internet] 2012;9:100–10.
16. Spurgeon T, Underhill C. Horticultural therapy – aspects of land use for the mentally handicapped: a system of planning for the requirements of the mentally handicapped gardener. Int J Rehabil Res [Internet] 1979;2:343–52.
17. Kamioka H, Tsutani K, Yamada M, Park H, Okuizumi H, Honda T, et al. Effectiveness of horticultural therapy: a systematic review of randomized controlled trials. Complement Ther Med [Internet] 2014; 22:930–43.
18. Whelden T, Sawin EM. Therapeutic horticulture for dementia: a systematic review. J Gerontol Nurs [Internet] 2023;49:49–52.
19. Allali G, Verghese J. Management of gait changes and fall risk in MCI and dementia. Curr Treat Options Neurol [Internet] 2017;19:29.
20. Cieślik B, Jaworska L, Szczepańska-Gierach J. Postural stability in the cognitively impaired elderly: a systematic review of the literature. Dementia [Internet] 2019;18:178–89.
21. Kuan Y-C, Huang L-K, Wang Y-H, Hu C-J, Tseng I-J, Chen H-C, et al. Balance and gait performance in older adults with early-stage cognitive impairment. Eur J Phys Rehabil Med [Internet] 2021;57:560–7.
22. Kostic E, Kwak K, Kim D. Changes in sensory, postural stability and gait functions depending on cognitive decline, and possible markers for detection of cognitive status. BMC Med Inform Decis Mak [Internet] 2022;22:252.
23. Caliskan H, Sahin UK, Baydan M, Ozsurekci C, Aycicek S, Dogrul T, et al. Balance performance measured by posturography in mild-moderate Alzheimer's disease: an undervalued assessment. Geriatr Nurs [Internet] 2023;53:33–9.
24. Chen T-Y, Janke MC. Gardening as a potential activity to reduce falls in older adults. J Aging Phys Act [Internet] 2012;20:15–31.
25. Heród A, Szewczyk-Taranek B, Pawłowska B. Therapeutic horticulture as a potential tool of preventive geriatric medicine improving health, well-being and life quality – a systematic review. Folia Hortic [Internet] 2022;34:85–104.
26. Folstein MF, Folstein SE, McHugh PR. Mini-mental state. J Psychiatr Res [Internet] 1975;12:189–98.
27. Tombaugh TN, McIntyre NJ. The Mini-Mental State Examination: a comprehensive review. J Am Geriatr Soc [Internet] 1992;40:922–35.
28. Shumway-Cook A, Woollacott MH. Motor control. In: Theory and practical applications. Baltimore: Lippincott Williams and Wilkins; 2001.
29. Mancini M, Horak FB. The relevance of clinical balance assessment tools to differentiate balance deficits. Eur J Phys Rehabil Med 2010;46: 239–48.
30. Guralnik JM, Ferrucci L, Pieper CF, Leveille SG, Markides KS, Ostir GV, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci [Internet] 2000;55:M221–31.
31. Cesari M, Kritchevsky SB, Penninx BW, Nicklas BJ, Simonsick EM, Newman AB, et al. Prognostic value of usual gait speed in well-functioning older people – results from the health, aging and body composition study. J Am Geriatr Soc 2005;53:1675–80.
32. Lamb SE, Jørstad-Stein EC, Hauer K, Becker C; On behalf of the Prevention of Falls Network Europe and Outcomes Consensus Group. Development of a common outcome data set for fall injury prevention trials: the prevention of falls network Europe consensus. J Am Geriatr Soc [Internet] 2005;53:1618–22.
33. Kovács E, Sztruhár Jónásné I, Karóczi CK, Korpos A, Gondos T. Effects of a multimodal exercise program on balance, functional mobility and fall risk in older adults with cognitive impairment: a randomized controlled single-blind study. Eur J Phys Rehabil Med 2013;49:639–48.
34. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol [Internet] 2006;3:77–101.
35. Parveen H, Noohu MM. Evaluation of psychometric properties of Tinetti performance-oriented mobility assessment scale in subjects with knee osteoarthritis. Hong Kong Physiother J 2016;36:25–32.
36. Braun T, Thiel C, Schulz R-J, Grüneberg C. Responsiveness and interpretability of commonly used outcome assessments of mobility capacity in older hospital patients with cognitive spectrum disorders. Health Qual Life Outcome 2021;19:68.
37. Kemoun G, Thibaud M, Roumagne N, Carette P, Albinet C, Toussaint L, et al. Effects of a physical training programme on cognitive function and walking efficiency in elderly persons with dementia. Dement Geriatr Cogn Disord [Internet] 2010;29:109–14.
38. Christofoletti G, Oliani MM, Gobbi S, Stella F, Bucken Gobbi LT, Renato Canineu P. A controlled clinical trial on the effects of motor intervention on balance and cognition in institutionalized elderly patients with dementia. Clin Rehabil [Internet] 2008;22:618–26.
39. Kong L, Zhang X, Zhu X, Meng L, Zhang Q. Effects of Otago Exercise Program on postural control ability in elders living in the nursing home: a systematic review and meta-analysis. Medicine [Internet] 2023;102: e33300.
40. Bossers WJR, van der Woude LHV, Boersma F, Hortobágyi T, Scherder EJA, van Heuvelen MJG. A 9-week aerobic and strength training program improves cognitive and motor function in patients with dementia: a randomized, controlled trial. Am J Geriatr Psychiatry [Internet] 2015;23:1106–16.

41. Miu DKY, Szeto SL, Mak YF. A randomised controlled trial on the effect of exercise on physical, cognitive and affective function in dementia subjects. Asian J Gerontol Geriatr 2008;3:8–16.
42. Telenius EW, Engedal K, Bergland A. Effect of a high-intensity exercise program on physical function and mental health in nursing home residents with dementia: an assessor blinded randomized controlled trial. PLoS One [Internet] 2015;10:e0126102.
43. Toots A, Littbrand H, Lindelöf N, Wiklund R, Holmberg H, Nordström P, et al. Effects of a high-intensity functional exercise program on dependence in activities of daily living and balance in older adults with dementia. J Am Geriatr Soc [Internet] 2016;64:55–64.
44. Sondell A, Littbrand H, Holmberg H, Lindelöf N, Rosendahl E. Is the effect of a high-intensity functional exercise program on functional balance influenced by applicability and motivation among older people with dementia in nursing homes? J Nutr Health Aging [Internet] 2019; 23:1011–20.
45. Wu VX, Chi Y, Lee JK, Goh HS, Chen DYM, Haugan G, et al. The effect of dance interventions on cognition, neuroplasticity, physical function, depression, and quality of life for older adults with mild cognitive impairment: a systematic review and meta-analysis. Int J Nurs Stud [Internet] 2021;122:104025.
46. Tao D, Awan-Scully R, Ash GI, Pei Z, Gu Y, Gao Y, et al. The effectiveness of dance movement interventions for older adults with mild cognitive impairment, Alzheimer's disease, and dementia: a systematic scoping review and meta-analysis. Ageing Res Rev [Internet] 2023;92:102120.
47. Teri L, Logsdon RG. Identifying pleasant activities for Alzheimer's disease patients: the pleasant events schedule-AD. Gerontol [Internet] 1991;31:124–7.
48. Soga M, Gaston KJ, Yamaura Y. Gardening is beneficial for health: a meta-analysis. Prev Med Rep [Internet] 2017;5:92–9.
49. Jing W, Willis R, Feng Z. Factors influencing quality of life of elderly people with dementia and care implications: a systematic review. Arch Gerontol Geriatr 2016;66:23–41.
50. Telenius E, Engedal K, Bergland A. Physical performance and quality of life of nursing-home residents with mild and moderate dementia. Int J Environ Res Publ Health 2013;10:6672–86.